Scheme of Instruction 2018-19

Contents

A. Scheme of Instruction

Preface

The “Scheme of Instruction” (SoI) and “Student Information Handbook” (Handbook) contain the courses and rules and regulations related to student life in the Indian Institute of Science. The courses listed in the SoI and the rules in the Handbook are primarily meant for post-graduate students of the Institute. Undergraduate students areallowed to credit or audit the courses listed in the SoI.

The course listings are in conformance with the Divisional structure of the Institute, with the courses of each department of a Division listed in a separate subsection. For instance, all courses of the Aerospace Engineering department have the prefix AE, and are listed in the Aerospace Engineering subsection within the Mechanical Sciences Division. The only exception to this pattern is the Electrical Sciences Division, where the courses are organized under the sub-sections E0 through E9, according to the areas to which they belong. For instance, all Computer Science and Automation courses of the Electrical Sciences Division have the prefix E0, and are found in the corresponding sub-section, although the instructors come from all four departments of the division. The course codes are given in the Table of Contents.

The listing of each course consists of the course number, the title, the number of credits and the semester. The course number indicates both the department and the level of the course. For instance, MA 205 indicates that the course is offered by the Mathematics department and is at the 200 level. Such 200 level courses are either basic or second level graduate courses. The 300 level courses are advanced courses primarily meant for research scholars, but can also be taken by course students who have the appropriate background; these courses can be taken only with the consent of the instructor. Most courses are offered only once a year, either in the August or in the January semester. A few courses are offered in the summer term.

The number of credits is given in the form M:N, where Mindicates the number of lecture credits and Nthe number of laboratory credits. Each lecture credit corresponds to one lecture hour per week, while each laboratory credit corresponds to a 3-hour laboratory class. Thus, a course with 2:1 credits indicates that ithas 2 lecture hours and one 3-hour laboratory session each week, anda course with 3:0 credits indicates a course with 3 lecture hours and no laboratory session.

The Institute offers research-based doctoral programmes and Master’s programmesthat are both course-based and research-based. Eachcourse-based Master’s programme consists of core courses, electives and a dissertation project. Details of the requirements can be found under the course listing of the departments or divisions that offer them. Each student is assigned a Faculty Advisor, who willadvise him/her in selectingand droppingcourses, and monitor progress through the academic program. In order to register for a course, thestudent needs the approval of both the faculty advisor and the course instructor. The number and type of courses taken in the first and subsequent semesters depend on the programme and department the student is registered in – the Faculty Advisor and the Department Curriculum Committee (DCC) will guide the students on the core and elective courses they should register for. Students are permitted to claim an exemption from core courses on the basis of having taken them earlier. Details of how to claim such an exemption are given in the later part of this book.

The Institute follows a grading system, with continuous assessment. The course instructor first aggregates the individual marks of each student from the class tests, assignments and final examination scores. These marks are then mapped to letter grades, and only the grade is announced. The point values of grades are as follows: A+:10,A: 9, B+: 8, B: 7, C:6, D:5, F: 0. Thegrades A+ through D are passing grades, and F is a failing grade.

All the course-based programmes have a specified set of core courses.The doctoral and research-based Master’s programmes may have specific core courses, which depend on the division and department.Students in research programmes have to take a minimum number of credits as part of their Research Training Program (RTP). For PhD studentsin Science, the RTP consists of a minimum of 12 credits. For PhD studentsin Engineering who join with a Master’s degree in Engineering, the RTP requirement is a minimum of 12 credits. For PhDstudents in Engineering who join with aBachelor’s degree in Engineering or a Master’s degree in Science, the RTP consists of a minimum of24 credits. Similar RTP requirements apply for students who upgrade or continue their registration from the Masters programmes of the Institute. For the research-based Master’s degree, the RTP consists of minimum 12 credits. The Integrated PhD programme has 64 credits. Research students have the option of crediting courses beyond the RTP requirement.

Detailed information with regard to the regulations of the various programmes and the operation of different aspects of Institute activities are given in the second part of the Handbook. Students are urged to read this material carefully, so that they are adequately informed.

31st July 2018
Bangalore560012

Prof. Prabhu R Nott
Chair
Senate Curriculum Committee

Information on the number of credits to be registered at various levels for Different programme

MTech/MDes/MMgt programme (2 years duration)
Minimum number of credits for completion :64

Core courses	15-30 at 200 level	
Dissertation Project	19-32	
Electives *	15-24	Balance to make up the minimum of 64 (at 200 level and above)

MDes programme (2 years duration)
Minimum number of credits for completion: 64

Core courses	36	at 200 level
Electives*	12	at 200 level and above
Dissertation Project	16	

Research programmes
Research Training Programme

(i) PhD Science : 12 credits (Ph D along with Master additional 12 credits (12+12)
(ii) PhD in Engineering Faculty with

(a) ME/MTech qualification: 12 credits
(b) MTech (Research) qualification: 12 credits
(c) BE/BTech qualification, and upgradingfrom MTech (Research) to PhD: 24 credits
(d) BE/BTech qualification, and transferringfrom MTech to PhD: 24credits
(e) BE/BTech/MSc qualification : 24 credits

<u>Note</u>: For cases (c) and (d) above,the committee approving the conversionis empowered to stipulate that the student take additional credits

(iii) MTech (Research): 12-21 credits (with 3 Maths credits)

(iv) Integrated PhD:Minimum of 64 credits

Division of Biological Sciences

Preface :

This Division includes the Department of Biochemistry, Centre for Ecological Sciences, Department of Microbiology and Cell Biology, Molecular Biophysics Unit, Department of Molecular Reproduction, Development and Genetics, Centre for Neurosciences, Centre for Infectious Disease Research and the Central Animal Facility. Students from a variety of disciplines such as biology, chemistry, physics and medicine are admitted into the Division for research work leading to a PhD degree.

Each Department/Centre/Unit offers courses on specialized topics designed to provide students with the necessary theoretical background and introduction to laboratory methods. There are specific requirements for completing the Research Training Programme for students registering for research conferments at the Institute. For individual requirements, the students are advised to approach the Departmental Curriculum Committee.

The Department of Biochemistry offers a programme of study concentrating on a molecular approach towards understanding biological phenomena. The programme of instruction consists of lectures, laboratory work, and seminar assignments. In addition to formal course work, students are required to participate in group seminars, departmental seminars and colloquia.

The Center for Ecological Sciences has excellent facilities for theoretical as well as experimental research in plant and animal ecology and the social behavior of insects. The programme of instruction consists of lectures, laboratory work, seminars and special assignments.

The Department of Microbiology and Cell Biology offers courses in microbiology, infectious diseases, eukaryotic genetics, advances in immunology, plant and cell culture, and recent advances in molecular biology and genetic engineering. The students are expected to participate in seminars on recent advances in these fields.

The Molecular Biophysics Unit offers courses which cover recent developments in molecular biophysics, biopolymer conformation, structure and interactions of biomolecules and biophysical techniques.

The courses offered in the Department of Molecular Reproduction, Development and Genetics include those on endocrinology, reproduction signal transduction, genetics, gene expression and development.

The research interests in the Centre for Neuroscience spans from molecules to behavior. The courses offered would enable the students to gain fundamental knowledge in molecular and cellular neuroscience, systems and cognitive neuroscience. In addition, students will be expected to actively participate in seminars, journal clubs and lab rotations.

The Centre for Infectious Disease Research (CIDR) is involved in two primary activities: First, providing the intellectual and infrastructural support for infectious disease research. Second, enable researchers to perform studies in the Bio-safety Level-3 (BSL-3) facility, a state-of-the-art bio-containment space to perform research with high infectious organisms, e.g. Mycobacterium tuberculosis etc.

The Central Animal Facility provides standardized pathogen free, conventionally bred animals for biochemical experiments and also has facilities for research involving non-human primates.

Prof. Umesh Varshney
Chairman, Division of Biological Sciences

Integrated PhD (Biological Sciences)

Course Work :

Core Courses: 19 credits

DB 201 2:0	Mathematics and Statistics for Biologists
DB 202 2:0	General Biology
DB 207 0:5	Laboratory
BC 203 3:0	General Biochemistry
MB 201 2:0	Biophysical Chemistry
MC 203 3:0	Microbiology
RD 201 2:0/	
DB 204	Genetics

Projects: 16 Credits :

DB 212 0:4	Project - I
DB 225 0:6	Project - II
DB 327 0:6	Project - III

Elective Courses: 29 Credits
(For a total of 64 credits)

DB 203 (AUG) 3:0

General Biochemistry

Biochemistry of carbohydrates and lipids. Cell membrane: structure and function. Metabolism: basic concepts and design, glycolysis and citric acid cycle, oxidative phosphorylation, bioenergetics, fatty-acid metabolism, integration and regulation of metabolism, pentose phosphate pathways and gluconeogenesis. Photosynthesis. Protein translation and regulation, cellular protein transport and protein turnover, biosynthesis and catabolism of amino acids and nucleotides, signal transduction. DNA structure, replication and repair. Transcription, regulation of gene expression in prokaryotes and eukaryotes. Recombinant DNA technology.

Sathees C. Raghavan, Patrick D Silva, Ganesh Nagaraju

Stryer L.,Biochemistry (4th Edn),David L Nelson and Michael M Cox, Lehninger Principles of Biochemistry, 3rd Edn, Worth Publishers, 2000.,W. H. Freeman and Company,1995.

DB 201 (AUG) 2:0

Mathematics and Statistics for Biologists

Calculus: functions, limits and continuity, differentiation, integration, transcendental functions. Linear Algebra: vectors, matrices, determinants, linear equations. Statistics: elements of probability theory, discrete and continuous distributions, measures of central tendency, variability, confidence intervals, formulation of statistical hypotheses, tests of significance.

Sekar K, Supratim Ray

Biological Instructor,Biological Instructor,Biological Instructor

DB 202 (AUG) 2:0

GENERAL BIOLOGY

Biology and the natural sciences; Growth of biological thought; Matter and life; Origin of life; History of life on earth; Bacteria and Protists; Fungi and other primitive plants; Seed bearing plants; Animals without back-bones; Insects, Vertebrates, Phylogeny and Systematics; Mechanisms of Evolution; Chemical basis of life; Cellular basis of life; Selected topics in plant and animal physiology; Selected topics in plant and animal ecology; Introduction To Neurophysiology with Topics In General Physiology; Behavioral ecology and sociobiology; Biological diversity on earth; Complexity; Molecular versus Organismal approaches to solving problems in Science.

Renee M Borges

• Maynard Smith,J. The Theory of Evolution,Penguin Books (1993 edition),1958. • Bonner,J. T. Why Size Matters: From Bacteria to Blue Whales

DB 225 (AUG) 0:6

Project - II

Utpal Tatu, Dipshikha Chakravortty

DB 212 (JAN) 0:6

Biological Science

Dipshikha Chakravortty

DB 327 (JAN) 0:6

Biological Science

An independent research project to be conducted in the laboratory of a faculty member in the Division of Biology. It is desirable that the project be carried out in the laboratory where Project II was conducted.

Dipshikha Chakravortty

Dept of Biochemistry

BC 201 (AUG) 2:0

Cell Biology

Biogenesis of proteins in eucaryotes: targeting to intracellular organelles, post-translational modifications, cellular redox. Intracellular protein degradation: lysosomal and non-lysosomal. Nuclear organization and function, chromosome structure, function and inheritance. Regulation of the Cell cycle, dynamic molecular events during mitosis, cell-cell communication.

Utpal Tatu, Dipankar Nandi, Shikha Laloraya, Patrick D Silva

Alberts et al.,Molecular Biology of the Cell,Third edition,Garland Publ. Inc. 1994

BC 202 (AUG) 2:0

Proteins: Structure and Function

Purification and characterization of enzymes/proteins. Determination of primary/secondary/tertiary/quaternary structures. Conformational properties of polypeptide chains; Mechanism of Protein folding;. Enzyme catalysis – steady state kinetics, allosteric enzymes, kinetics of interactions of ligands, protein engineering, enzyme mechanisms.

Narasimha Rao D, Utpal Tatu, Nagasuma R Chandra

Creighton,T.G.,Proteins,W.H.Freeman,1993.

BC 203 (AUG) 3:0

General Biochemistry

Biochemistry of carbohydrates and lipids. Cell membrane: structure and function. Metabolism: basic concepts and design, glycolysis and citric acid cycle, oxidative phosphorylation, bioenergetics, fatty-acid metabolism, integration and regulation of metabolism, pentose phosphate pathways and gluconeogenesis. Photosynthesis. Protein translation and regulation, cellular protein transport and protein turnover, biosynthesis and catabolism of amino acids and nucleotides, signal transduction. DNA structure, replication and repair. Transcription, regulation of gene expression in prokaryotes and eukaryotes. Recombinant DNA technology.

Sathees C. Raghavan, Patrick D Silva, Ganesh Nagaraju, Purusharth Rajyaguru

Stryer L.,Biochemistry (4th Edn),W. H. Freeman and Company,1995,David L Nelson and Michael M Cox

BC 306 (AUG) 3:0

Essentials in Immunology

Adaptive and innate immunity, inflammation, antibody structure and function, the complement system, antigen - antibody interaction, cells and organs of the immune system, B cell activation, immunoglobulin genes, molecular basis of antibody diversity, T cell receptors, T cell activation, major histocompatibility complex, antigen processing and presentation, lymphokines, transcription factors, hypersensitivity, autoimmunity, immunological techniques. Immunological disorders and therapy

Dipankar Nandi, Sathees C. Raghavan, Sandeep M Eswarappa

Goldsby,R.A.,Kindt,T.J.,Osborne

BC 207 (JAN) 2:0

Proteomics in Practice

Course offers introduction to proteomics, 2D gel electrophoresis techniques for resolution of proteins, mass spectrometry principles and applications in proteomics. Study of post translational modifications, Databases (NCBI, Swiss-prot and MSDB) and their uses, software (protein pilot, mascot and gpm) uses for proteomic analysis. Introduction to quantitative proteomics and techniques (i-TRAQ and SILAC).

Utpal Tatu

Reiner Westermeier,Tom Nave,Proteomics :,Tools for the New Biology,by Daniel C Liebler

BC 205 (JAN) 2:0

Fundamentals of Physiology and Medicine

Introduction to human embryology and congenital anomalies (RB), Cardiovasculr system; Respiratory system; Endocrine system; Digestive system; Renal Physiology; Physiology and common Pathologies/disorders associated with these systems; Medical and surgical interventions (SME).

Sandeep M Eswarappa, Ramray Bhat

1. Ganong's Review of Medical Physiology,25th Edition (McGraw-Hill Education).,2. Guyton and Hall Textbook of Medical Physiology (Saunders Publication).,3. Harrison's Principles of Internal Medicine (McGraw -Hill Education).,4. Davidson's Principles and Practice of Medicine

BC 210 (JAN) 3:0

Molecular Basis of Ageing and Regeneration

Model systems for studying Ageing and Regeneration (such as Planaria, Hydra, Salamander); Role of cellular processes such as transcription, translation, posttranslational modifications; Signalling mechanisms; Cellular Senescence; Genetic basis of Ageing and longevity; Ageing and Diseases; Organ Senescence; Obesity/Diabetes/Cardiovascular diseases/Muscle degeneration; Interventions to delay ageing and/or enhance life span.

Varsha Singh, Purusharth Rajyaguru, Nagalingam Ravi Sundaresan

Principles of Regenerative Biology by Bruce Carlson.,Regeneration - Developmental Biology by Scott F Gilbert (6th Edition). Handbook of the Biology of Ageing,Seventh Edition,by Edward J Masoro (Editor),Steven N. Austad (Editor) 2010.

BC 302 (JAN) 3:0

Current Trends in Drug Discovery

Introduction to the process of Drug discovery, Principles of drug action, Biochemical pharmacology, drug absorption, distribution, metabolism and elimination, bioavailability. Drug receptors and their interactions, dose-response relationships, pharmacokinetics & pharmacodynamics. Use of genomics and proteomics for understanding diseases at the molecular level. Brief introduction to Systems biology, Strategies for target discovery, high throughput screening using genomics, proteomics and bioinformatics for target and lead identification. Molecular recognition, drug and target structures and chemoinformatics. Druggability, protein-ligand interactions, structure-based ligand design. Lead Identification, Lead optimization and design, Binding site characterization, docking and clustering. Pharmacophore-based approaches, QSAR. Pharmacogenomics & Variability in Drug Response, biochemical mechanisms of drug resistance, examples from current literature

Nagasuma R Chandra

Basic Principles of Drug Discovery and Development by Benjamin E Blass 2015,Structure Based Drug Discovery - An Overview by Roderick E. Hubbard (RSC Publication) 2006,Molecular Pharmacology from DNA to Drug Discovery by John Dickenson,Fiona Freeman,Chris Lloyd Mills

BC 209 (JAN) 2:0

Dessertation Project

The dissertation project is aimed at training students to review recent literature in specialized areas of research.students to review recent lit

Jayabaskaran C

Only BC Students,Biochemistry students,Biochemistry students

Centre for Ecological Sciences

EC 301 (AUG) 2:1

Animal Behaviour: Mechanisms and Evolution

History and classical ethology; sensory processing and neural maps; Learning and memory; hormones and behavior; behavioral genetics; optimality approaches and evolutionary models to understand strategies for foraging, competition, group living, sexual selection and mate choice, parental care and family conflicts, predator-prey interactions;theoretical, integrative and computational approaches to studying animal behaviour.

Maria Thaker

Alcock,J.,Animal Behaviour - An Evolutionary Approach (Sixth Edition),Sinauer Associates,1998.

EC 305 (AUG) 2:1

Quantitative Ecology: Research Design and Inference

The scientific process in ecology; framing ecological questions; elements of study design; confronting ecological models with data; understanding the nature of data; frequentist framework for statistical inference; basics of probability and probability distributions, point estimations, estimating uncertainty, linear regression, etc.

Kavita Isvaran, Vishwesha Guttal

Hilborn,R. and Mangel,M.,The Ecological Detective: Confronting Models with Data. Princeton University Press,Princeton

EC 302 (AUG) 2:1

Plant-Animal Interactions (Ecology, Behaviour and Evolution)

The sensory biology of the interaction between plants, their animal mutualists and parasites: vision, chemoreception, olfaction and multimodal signalling; energetics of plant–animal interactions; nectar, floral and vegetative scents and pollen chemistry; stable isotopes in the study of plant–animal interactions; mate choice in plants; evolution of floral and fruit traits; phenotypic plasticity and inducible defenses in plants; behavioural and physiological processes in generalist and specialist herbivores, pollinators and seed dispersers; co-evolutionary dynamics of symbiosis, mutualisms and arms races

Renee M Borges

Chittka,L. and Thompson,J. D. (Eds.),Cognitive Ecology of Pollination — Animal Behaviour and Floral Evolution. Cambridge University Press,2001.

EC 203 (JAN) 2:0

Ecology: Principles and Applications

Earth (geology, geography, climate); ecology and society; evolutionary underpinnings to the ecology of organisms; natural selection and sexual selection; population dynamics; plant–herbivore interactions; predator–prey interactions; competition and coexistence; succession; trophic interactions and trophic cascades; ecosystems; biogeochemical cycles; global change; ecological applications; biodiversity and conservation; quantitative tools (ecological modeling and an introduction to statistics)

Sumanta Bagchi

Begon,M.,C.R. Townsend,and J.L. Harper. Ecology: From Individuals to Ecosystems,(Fourth Edition) Wiley-Blackwell

EC 204 (JAN) 2:1

Evolutionary Biology

This course offers an in-depth, hands-on look at the basic principles of evolutionary biology, and discusses the recent advancements and the major ideas in the field. The course has a special emphasis on phylogenetics, population genetics, molecular evolution, genome evolution, and offers exposure to a wide range of theoretical and practical aspects for understanding the micro- and macroevolutionary processes that shape the diversity of life on earth.

Praveen Karanth K, Kartik Sunagar

Futuyma,D. J.,Evolutionary Biology (Third Edition),Sinauer Associates,1998.Li

EC 201 (JAN) 2:1

Theoretical and Mathematical Ecology

Basic elements of theoretical ecology, building and analyzing mathematical models of ecological systems, generating new ecological insights and hypotheses. Discrete and continuous population models; nonlinear dynamics and bifurcations in ecological models; incorporating stochasticity and space; random walks in ecology and evolution; game theory and ESS; Price equation and levels of selection.

Kavita Isvaran, Vishwesha Guttal

Hastings,A.,Population Biology: Concepts and Models,Springer,Turchin

Molecular Biophysics Unit

MB 214 (AUG) 3:0

Neuronal Physiology and Plasticity

Neuronal and synaptic physiology: exquisite insights from simple systems; history of technical advances: electrophysiology, imaging and computation; history of conceptual advances: excitable membranes, action potentials, ion channels, oscillations, synapses, behavioral neurophysiology; complexities of the mammalian neuron; dendritic structure; dendritic ion channels; active properties of dendrites; dendritic spikes and backpropagating action potentials; heterogeneity, diversity and degeneracy in the nervous system; hippocampus as an ideal system for assessing learning and memory; synaptic plasticity: short-term plasticity, long-term potentiation and depression; mechanisms underlying synaptic plasticity; intrinsic plasticity; mechanisms underlying intrinsic plasticity; issues in the credit-assignment problem on mechanisms behind learning and memory.

Rishikesh Narayanan

Prerequisites: None.~References: 1. "Foundations of Cellular Neurophysiology" by Daniel Johnston and Samuel Wu, MIT Press, 1995.~2. "Neuroscience" by Dale Purves, George J. Augustine, David Fitzpatrick, William C. Hall, Anthony-Samuel LaMantia, Richard D. Mooney, Michael L. Platt, Leonard E. White, Oxford University Press, 2017.~3. "The Hippocampus Book" by Per Andersen, Richard Morris, David Amaral, Tim Bliss and John O'Keefe. Oxford University Press, 2006.~4. "Dendrites" by Greg Stuart, Nelson Spruston and Michael Hausser. Oxford University Press, 2016. 5. "Synapses" by W. Maxwell Cowan, Thomas C. Südhof, Charles F. Stevens, The Johns Hopkins University Press, 2003. 6. "The synaptic organization of the brain" by Gordon Shepherd, Oxford University Press, 2004. 7. "Rhythms of the Brain" by Gyorgy Buzsaki, Oxford University Press, 2006.

MB 204 (AUG) 3:0

Molecular Spectroscopy and its Biological Applications

Principles and biological applications of UV-Vis, fluorescence, vibrational and circular dichroism spectroscopy. Mass spectrometry and basics of one- and two-dimensional NMR spectroscopy with applications to peptide and protein structure determination.

Siddhartha P Sarma, Ashok Sekhar

Horst Friebolin Basic One-and Two-Dimensional NMR Spectroscopy (Fourth Edition),Claridge T.D. W NMR High-Resolution NMR Techniques in Organic Chemistry - 3rd Edition,Kurt Wuthrich NMR of proteins and nucleic acids,Tinoco et al Physical Chemistry: Principles and Applications in Biological Sciences (5th Edition),Fred W. McLafferty and Frantisek Tureek-Interpretation of Mass Spectra:

MB 201 (AUG) 2:0

Introduction to Biophysical Chemistry

Basic thermodynamics, ligand binding and co-operativity in biological systems, kinetics, diffusion and sedimentation.

Raghavan Varadarajan

Tinoco,I.,Sauer,K.,Wang

MB 205 (AUG) 2:0

Introduction to X-ray Crystallography

Crystal symmetry. Symmetry elements and symmetry operations, point groups, lattice space groups. Production and properties of X-rays, diffraction of X-rays by crystals, Laue equations, Bragg's Law, Fourier transformation and structure factor, reciprocal lattice, experimental techniques, rotating crystals and moving film methods. Basic ideas of structure determination, Patterson and Fourier methods,powder diffraction.

Kaza Suguna, Aravind Penmatsa

Buerger,M.J.,Elementary Crystallography,Woolfson,M.M.

MB 206 (AUG) 3:0

Conformational and Structural aspects of biopolymers

Basic ideas on structure and conformation of simple molecules – structural features of proteins and nucleic acids, aspects of biomolecular forces. Higher order structural organization of proteins and nucleic acid.

Manju Bansal, Srinivasan N, Anand Srivastava

Ramachandran,G.N.,and Sasisekharan,V.,Advances in Protein Chemistry

MB 212 (JAN) 2:0

Electron microscopy and 3D image processing for Life Sciences

Objectives and basic working principles of different types of microscopes. Different types of electron microscopies and their applications.Basic introduction of electron microscopy physics and optics. Principles of image formation, Fourier analysis, Contrast Transfer Function and point spread function (electron scattering, phase contrast, electron–specimen interactions, electron diffraction). Characteristics of various advanced sample preparation, imaging, data collection techniques of bio-molecules for negative staining and cryo-electron microscopy. Theoretical, computational and practical aspects of various advanced 3D image processing techniques for all kinds of EM data (Random Conical Tilt Pair, Orthogonal Tilt pair, Single Particle Analysis, Subtomogram averaging). Cryo-EM map interpretation and data analysis, validation, molecular docking (use of Chimera, VMD) and application of Molecular Dynamics Flexible Fitting (MDFF)

Somnath Dutta

Basic knowledge in differential calculus, matrix, probability theory, basic physics like optics, light, modern physics, wave nature of electrons, electron physics, some programming knowledge and familiarity with Linux.,1. John J. Bozzola and Lonnie D. Russell (1992). Electron Microscopy (Jones & Bartlett Publishers). 2. Ray F. Egerton (2005). Physical Principles of Electron Microscopy: An Introduction to TEM, SEM, and AEM (Springer). 3. Elaine Evelyn Hunter and Malcolm Silver (1993). Practical Electron Microscopy: A Beginner's Illustrated Guide (Cambridge University). 4. Ludwig Reimer and Helmut Kohl (2008). Transmission Electron Microscopy: Physics of Image Formation (Springer).,5. John Kuo (2007). Electron Microscopy: Methods and Protocols (Methods in Molecular Biology) (Humana). 6. Earl J. Kirkland (2014). Advanced Computing in Electron Microscopy (Springer). 7. Gabor T. Herman and Joachim Frank (2014). Computational Methods for Three-Dimensional Microscopy Reconstruction (Birkhäuser Basel). 8. Joachim Frank (2006). Electron Tomography, (New York, Springer). 9. Joachim Frank (2006).,Three-Dimensional Electron Microscopy of Macromolecular Assemblies (New York, Oxford U. Press). 10. Joachim Frank (1996). Three-dimensional Electron Microscopy of Macromolecular Assemblies (San Diego, Academic Press).

MB 211 (JAN) 3:1

Multiscale Theory and Simulations of Biomolecular Systems

Theoretical and computational aspects of various advance sampling and free energy calculation methods (maximum work theorem, Jarzinsky equality, umbrella sampling, replica exchange, metadynamics, markov state model, etc).Continuum representation of solvent and calculation of electrostatic and non-electrostatic component of solvation free energy. Method development and application of multiscale coarse-graining methods such as force-matching, elastic network models, Inverse-Boltzmaan's method and relative entropy methods.

Anand Srivastava

Basic knowledge in statistical mechanics, thermodynamics and molecular simulation (and/or basic exposure to biomolecule conformations) Working knowledge of any one molecular dynamics tool. Books and references a. Michael P. Allen and Dominic J. Tidesley, Computer Simulation of Liquids (Oxford Science Publications), 1981 b. Andrew Leach, Molecular Modeling: Principles and Application(Princet Hall), 2001.,c. Christophe Chipot (Ed.) and Andrew Pohorille (Ed.), Free Energy Calculations (Springer), 2008 d. Gregory A. Voth (Ed.), Coarse-Graining of Condensed Phase and Biomolecular Systems (CRC Press), 2008 e. Mark Tuckerman, Statistical Mechanics: Theory and Molecular Simulation (Oxford Graduate Texts), 2010,f. Ken Dill and Sarina Bromberg, Molecular Driving Forces: Statistical Thermodynamics in Biology, Chemistry, Physics, and Nanoscience (Taylor and Francis), 2010 g. Gregory R. Bowman (Ed.), Vijay S. Pande (Ed.) and Frank Noé (Ed.), An Introduction to Markov State Models and Their Application to Long Timescale Molecular Simulation: Advances in Experimental Medicine and Biology (Springer),2013

MB 208 (JAN) 3:1

Theoretical and Computational Neuroscience

Need for and role of theory and computation in neuroscience, various scales of modelling, ion channel models, single neuron models, network and multi-scale models, models of neural plasticity. Oscillations in neural systems, central pattern generators, single neuron oscillators, network oscillators information representation, neural encoding and decoding, population codes, hierarchy and organization of sensory systems, receptive field and map modelling. Case studies, computational laboratory and projects

Rishikesh Narayanan, Arun P Sripati

Prerequisites: MB209, basic knowledge of linear algebra, probability, statistics and ordinary differential equations, and some programming knowledge.,Dayan, P., and Abbott, L.F., Theoretical Neuroscience: Computational and Mathematical Modeling of Neural Systems, The MIT press, 2005.,Koch, C., and Segev, I. (Eds), Methods in Neuronal Modeling: From Ions to Networks, The MIT press, Second Edn, 1998. Eric De Schutter (ed.), Computational modeling methods for neuroscientists, The MIT press, 2009. Eugene Izhikevich, Dynamical systems in neuroscience: The geometry of excitability and bursting, The MIT press, 2006. Doya, K., Ishii, S., Pouget, A., Rao, R.P.N. (Eds), Bayesian Brain: Probabilistic Approaches to Neural Coding, The MIT press, 2007.

MB 210 (JAN) 2:0

Peptides and Drug-Design

Organic reaction mechanisms; acids and bases; synthesis and properties of alpha, beta and gamma amino acids; conventional and contemporary ways of peptide and protein synthesis; synthesis and properties of cell-penetrating peptides; design of peptide mimics for drug-discovery, chemical genetics screening.

Jayanta Chatterjee

a. Norbert Sewald and Hans-Dieter Jakubke, Peptides: Chemistry and Biology, Second Edition, Wiley-VCH Verlag GmbH & Co. KGaA,2009.,Miguel Castanho and Nuno C. Santos (Eds), Peptide Drug Discovery and Development: Translational Research in Academia and Industry, Wiley-VCH Verlag GmbH & Co. KGaA,2009,Selected review articles.

MB 305 (JAN) 3:0

Biomolecular NMR Spectroscopy

Basic theory of NMR spectroscopy. Classical and theoretical descriptions of NMR spectroscopy. Product operator formalism for description of multi-pulse homo-nuclear and hetero-nuclear NMR experiments. Multidimensional NMR spectroscopy, description of basic homo-nuclear 2D NMR experiments useful for structure determination of biological macro-molecules. Experimental aspects of homo-nuclear NMR spectroscopy: data acquisition, processing and interpretation of 2D homo-nuclear spectra. Principles of hetero-nuclear NMR spectroscopy. Analysis of 3D and 4D hetero-nuclear isotope edited NMR pulse sequences. Introduction to relaxation and dynamic processes (chemical and conformational processes) that affect NMR experiments.

Siddhartha P Sarma, Ashok Sekhar

Cavanaugh,J.,Fairbrother,W.J.,Palmer

MB 303 (JAN) 3:0

Elements of Structural Biology

Methods for determining the three dimensional structures of biological macromolecules by X-Ray Crystallography. Biophysical methods to understand structures of proteins and protein-DNAcomplexes.

Balasubramanian Gopal

Kensal, E. Van Holde et al., Principles of Physical Biochemistry, Second Edn, Pearson Education Intl.,Cantor, C.R., and Schimmel, P.R., Biophysical Chemistry, Vols. I-III, W H Freeman and Co., San Francisco, 1980.,Research papers and reviews

MB 207 (JAN) 2:0

DNA-Protein interaction, Regulation of gene expression, Nanobiology

Basic concepts on structural basis for macromolecular recognition. Concept of charge in macromolecules, specific and non-specific recognition, symmetry in DNA-protein recognition, structural ensembles, co-operativity, specific examples, story of lambda, restriction enzyme recognition, t-RNA synthetase recognition, promoter-RNA polymerase interaction, inducers and repressors, action at a distance. Single molecular paradigm. Methods to follow nanobiology. DNA-protein recognition at the level of single molecules.

Dipankar Chatterji

Lewin,B.,Genes X,Oxford.~McWright and Yamamoto,Transcriptional Regulations I and II

Dept of Microbiology and Cell Biology

MC 206 (AUG) 2:0

RNA BIOLOGY

A basic concept on the Biology of RNA with primary emphasis on eukaryotic systems. Concept of RNA world; Types of RNA- their biogenesis and functions, chemical aspects of RNA and its building blocks; Transcription mechanisms, coupled transcription and post transcriptional processing: splicing & polyadynylation, hnRNPs, Posttranscriptional control mechanism; RNAses and inhibitors, Ribozymes. RNA stability, mRNA modifications, translation independent role of mRNA, Role of RNA in protein biosynthesis; Translational control of gene expression. Non-coding RNAs: structure and function, RNA interference: siRNA and miRNAs; RNA structure and prediction, evolution of RNA sequences RNA editing. Discovery of basic molecular mechanisms from study of RNA viruses, RNA binding proteins, RNA-protein recognition and interactions; RNA viruses: regulation of gene expression; RNA in pathogenesis, its potential use as a drug target as well as its use as a drug.

Saumitra Das, Saibal Chatterjee, Purusharth Rajyaguru

Gestland,R. F,Cech,T. R,& Atkins J. F.

MC 205 (AUG) 2:0

Host-Pathogen interactions - Bacteria, Viruses and Protozoan Parasites

Secretion systems of bacteria: Type I, II, III, IV, V. Overview of ABC exporters and importers, plant pathogen interactions, virulence gene expression, intracellular pathogenesis. Pathogen persistence, signaling by bacterial and viral components. Innate and adaptive immunity to bacterial pathogens. Quorum sensing, biofilm formation, and its role in pathogenesis. Viral immune evasion mechanisms such as functional mimicry of host complement proteins, secretion of chemokine and cytokine-like molecules, inhibition of NF-?B and apoptosis, inhibition of serine proteases of the host antigen presenting cells to suppress antigen presentation, inhibition of MHC class I presentation of viral antigens, inhibition of host secretory pathway, prevention of phagosome acidification, antigenic variation and suppression of TH1 responses by protozoan pathogens, role of host TRIM5 family proteins in controlling HIV by mutation of viral RNA, ds-RNA and non-capped 5' end mediated recognition of pathogens by the host. Viral vectors, vaccines and drugs.

Vijaya S, Dipshikha Chakravortty

David G. Russell and Siamon Gordon,Phagocyte-Pathogen Interactions: Macrophages and the Host Response to Infection,ASM Press,2009. Knipe,D.M.

MC 203 (AUG) 3:0

Essentials in Microbiology

Fascinating world of microbes; Principles of microscopy; Microbial taxonomy, Microbial diversity, evolution and genomics; Mechanisms of horizontal gene transfer including genome transplantation, Microbes as model systems of development, Microbes as bioreactors and sensors; bioremediation; bacterial cell structure and function; Bacterial physiology and nutrition; Bacteriophages, Plasmids and Transposons; Understanding and combating bacterial pathogenesis; Antibiotics- mechanisms of drug resistance and mode of action; Quorum sensing and biofilms; Host-pathogen interactions and mechanisms of immune surveillance; PRR and their role in pathogenesis; TH subsets and modulation by pathogens; Diagnostics and vaccine development.

Balaji Kithiganahalli, Dipshikha Chakravortty, Amit Singh

Stanier,R.V.,Adelberg E.A and Ingraham J.L.,General Microbiology,Macmillan Press

MC 212 (AUG) 2:0

Advances in Cell Biology

Concepts: Prokaryotic and eukaryotic membrane structure, composition, organization and transport; Organelle structure, function and their biogenesis includes nucleus, endoplasmicreticulum, Golgi, endosomes, lysosomes and lysosome-related organelles,autophagosomes,peroxisomes, mitochondria and chloroplasts; Protein trafficking in-and-out of the organelles; Cytoskeletal elements and organization; Cell adhesion and junctions; Intra and extra cellular signaling;Cell cycle, cell division (asymmetric and symmetric) and stem cells; Cell death and protein homeostasis pathways andCellular diseases. Methods: Introduction and evolution of light microscopy; Electron microscopy; Cytohistochemistry; Flow cytometry; Pulse-chase and subcellular fractionation; Proteomics and Protein-protein interaction approaches and genome-wide RNAi or small molecular screens to study the various cellularpathways

Subba Rao Gangi Setty, Sachin Kotak

Molecular Biology of The Cell,Fifth edition,Alberts,B.,Johnson

MC 207 (AUG) 3:0

Molecular Biology

Genome organisation, structure and complexity.Chromatinstructure and remodelling.Protein nucleic acids interactions. DNA replication in prokaryotes and eukaryotes: general rules, mechanisms, andregulation. DNA modifications in epigenetic control of biologicalprocesses.DNA repair and recombination.Mechanisms and machinery of transcription in prokaryotes and eukaryotes.RNA splicing and editing.Catalytic RNAs.Transcriptional and translational regulation of geneexpression.Protein splicing and repair.Small RNAs: biogenesis, and theirmodes of action in regulation of gene expression and chromatin architecture. Group discussions and seminars on current topics in MolecularBiology

Umesh Varshney, Saibal Chatterjee

Lewin’s GenesX,Lewin,B.,Krebs,J.E.

MC 208 (AUG) 3:0

Principles of Genetic Engineering

Growth and maintenance of bacteriophages and bacterial strains containing plasmids. Enzymes used in genetic engineering. Vectors used in molecular cloning and expression of genes, promoter analyses, and gene targeting in bacterial, mammalian, human, and plant systems. DNA, RNA, and protein isolation, purification, and fractionation methods. Radioactive and nonradioactive labelling of nucleic acids and proteins, and detection. Nucleic acids hybridisation methods. Transformation and transfection methods. Gene and cDNA cloning methods. In vitro genome packaging systems and construction of genomic DNA and cDNA libraries. Detection and characterisation methods for genes and chromosomes. Nucleic acids sequencing methods. Methods for protein analysis, protein-nucleic acid, and protein-protein interactions. Site-specific mutagenesis in vitro and in vivo. Random mutagenesis methods in vitro and in vivo. Genome engineering methods. Polymerase chain reaction (qualitative and quantitative), methods, and applications. Antisense technology and RNA silencing techniques. DNA and Protein microarrays. Methods to generate transgenic bacteria/animals/plants. Applications of Genetic Engineering Methods in Medicine and Agriculture.

Ajit Kumar P, Nagalingam Ravi Sundaresan

J. Sambrook and D. W. Russell,Molecular Cloning: A Laboratory Manual,3rdEdn: Vol. I,II,& III

MC 210 (JAN) 2:0

Molecular Oncology

Immortalization, transformation, and metastasis. Genetic instability, mutation, deletion, insertion, aneuploidy, chromo-some translocation and gene amplification. Cell cycle and cancer, cell cycle checkpoints – G1 and S checkpoint, G2 and M checkpoint, cyclins and cyclin dependent kinases, CDK inhibitors – p16, p21 and p27. Oncogenes, growth factors, growth factor receptors, G protein/signal transduction, tyrosine and serine/threonine kinases and transcription factors. Tumor suppressor genes: p53, RB, BRCA1, BRCA2, APC and WT1. Mismatch repair, telomerase, DNA methylation, protein phosphorylation/dephosphorylation and degradation events. Tranformation by RNA and DNA tumor viruses (adenovirus, simian virus 40 and human papilloma virus). Oncogene - tumor suppressor interactions, apoptosis and cancer. Cancer gene therapy.

Kumaravel Somasundaram, Annapoorni Rangarajan

Robert A Weinberg. The Biology of Cancer,Garland Science Publishing,New York.,II,& III

MC 202 (JAN) 2:0

Eukaryotic Developmental Genetics

Logic and techniques of molecular genetic analysis. Understanding interaction networks using genetics and genomics. Illustrating the application of genetic analysis to specific developmental pathways in model eukaryotic organisms. Some examples are regulation of cell cycle, genetic and epigenetic mechanisms of cell fate determination, and signaling pathways in development.

Usha Vijayraghavan, Utpal Nath, Upendra Nongthomba

• Current Opinion in Genetics and Development/ Cell Biology/ Plant Biology • Trends in Genetics/ Cell Biology/ Biochemistry • Principles of Development by Wolpert and co-authors • Mechanisms in Plant Development by Leyser and Day • Plant Physiology by Taiz and Zeiger • Ecological Developmental Biology by Scott Gilbert and David Epel

MC 211 (JAN) 2:0

Molecular basis of Ageing and Regeneration

Mechanisms of Ageing and Regeneration; Model systems for studying Ageing and Regeneration; Role of cellular processes such as transcription, translation, posttranslational modifications; Signalling mechanisms; Cellular Senescence; Genetic basis of Ageing and longevity; Ageing and Diseases; Organ Senescence; Obesity/Diabetes/Cardiovascular diseases/Muscle degeneration; Interventions to delay ageing and/or enhance life span

Varsha Singh, Purusharth Rajyaguru, Nagalingam Ravi Sundaresan

1. Principles of Regenerative Biology by Bruce Carlson. http://www.sciencedirect.com/science/book/9780123694393 2. Regeneration – Developmental Biology by Scott F Gilbert (6th edition) 3. Hand book of the Biology of Aging,Seventh Edition,by Edward J. Masoro,Steven N. Austad,2010 4. Molecular Biology of Aging (Cold Spring Harbor Monograph Series)

Dept of Molecular Reproduction, Development and Genetics

RD 201 (AUG) 2:0

Genetics

Transmission and distribution of genetic materials, dominance relations and multiple alleles, gene interaction and lethality. Sex linkage, maternal effects and cytoplasmic heredity, cytogenetics and quantitative inheritance. Elements of developmental and population genetics.

Mahadevan S, Srimonta Gayen

Genetics 3rd edition by M. Strickberger,Molecular Genetics 2nd edition by G. Stent and R. Calendar,Genetic Switch 2nd edition by M. Ptashne

RD 210 (JAN) 2:0

Fundamentals of Physiology and Medicine

Introduction to anatomy, histology, evolutionary medicine and clinical examinations, general human embryology, physiological and pathological aspects of cardiovascular system, respiratory system, renal system, alimentary system, Endocrine system.

Sandeep M Eswarappa, Ramray Bhat

Ganong's Medical Physiology, 23rd Edition,Junqueira's Basic Histology, 13th Edition,Robbins Basic Pathology, 9th Edition

RD 209 (JAN) 2:0

Molecular basis of ageing and regeneration

Mechanisms of Ageing and Regeneration, Model systems for Regeneration; Role of cellular process such as transcription, translation, posttranslational modifications, Signalling mechanisms; neurogenesis, Cellular senescence; Model systems for studying Ageing; Genetic basis if Ageing and longevity; Ageing and diseases; immunosenescence and inflammation, Organ Senescence; Obesity/Diabetes/Cardiovascular diseases/Muscle degeneration; Interventions to delay ageing and/or enhance life span (caloric restriction)

Varsha Singh, Purusharth Rajyaguru, Nagalingam Ravi Sundaresan

Principles of Regenerative Biology by Bruce Carlson.,Regeneration - Developmental Biology by Scott F Gilbert (6th Edition).,Handbook of the Biology of Ageing, Seventh Edition, by Edward J Masoro (Editor), Steven N. Austad (Editor) 2010.,Molecular Biology of Ageing (Cold Spring Harbor Monograph Series), by Leonard Guarente, 2007.,Biology of Ageing: Observations and Principles of Robert Arking, 2006.

RD 205 (JAN) 2:0

Human Molecular Genetics

Human chromosomes, clinical cytogenetics, tools of human molecular genetics, organization of human genome, pattern of Mendelian inheritance, genomic imprinting, uniparental disomy and human genetic disorders, X-inactivation, genetic variation, polymorphism and mutation, gene mapping and linkage analysis, biochemical basis of genetic diseases, genetics of cancer, genetic counseling, prenatal diagnosis

Arun Kumar

Human Molecular Genetics by Tom Strachan & Andrew P Read,Thompson & Thompson Genetics in Medicine by RL Nussbaum, RR McInnes & HF Willard,Human Genetics: Problems & Approaches by F Vogel & AG Motulsky

RD 206 (JAN) 2:0

Molecular Oncology

Introduction to cancer biology. Immortalization, transformation, metastasis. Causes of cancer, initiators and promoters, carcinogens, tumor viruses, sporadic and familial cancer. Genetic alterations in cancer. Molecular mechanisms of carcinogenesis: cell culture and animal models. Cancer as a tissue: angiogenesis, role of stroma. Cell cycle and cancer: cell cycle checkpoints, cyclins and cyclin dependent kinases, CDK inhibitors. Oncogenes: growth factors, growth factor receptors, G protein/signal transduction, tyrosine and serine/threonine kinases and transcription factors. Tumor suppressor genes. Mismatch repair, telomerase, DNA methylation, protein phosphorylation/dephosphorylation and degradation events. Transformation by RNA and DNA tumor viruses: adenovirus, simian virus 40 and human papilloma virus, oncogene-tumor suppressor interactions. Apoptosis and cancer. Cancer and stem cells

Kumaravel Somasundaram, Annapoorni Rangarajan

Weinberg, R., 2013. The biology of cancer. Garland science. (Book),Hanahan, D. and Weinberg, R.A., 2011. Hallmarks of cancer: the next generation. Cell, 144(5), pp.646-674. (review article),Pecorino, L., 2012. Molecular biology of cancer: mechanisms, targets, and therapeutics. Oxford university press.

Centre for Neuroscience

NS 201 (AUG) 3:0

Fundamentals of Systems and Cognitive Neuroscience

Neuroanatomy, brain imaging, Biophysics of action potentials, sensation and perception, attention, decision making, motor systems and executive control, space and memory

Aditya Murthy, Arun P Sripati, Supratim Ray, Sridharan Devarajan

None

NS 202 (AUG) 3:0

Fundamentals of Molecular and Cellular Neuroscience

Molecular basis of neuronal development, neuronal transmission, synaptic organisation and its relationship to synaptic physiology, small animal behavior, learning and memory and neurological disorders.

Balaji J, Narendrakumar Ramanan, Deepak Kumaran Nair

None

NS 204 (AUG) 0:1

Neuroscience Practicum 1

Laboratory experience to enable the student gain exposure to research ....

Deepak Kumaran Nair, Sridharan Devarajan

Registration open to CNS First Year graduate students only,None,None

NS 203 (JAN) 3:0

Optical Spectroscopy and Microscopy

Transition probabilities; Time dependent perturbation theory; Interaction with strong fields, Second Quantization; Origin of Spontaneous emission; characteristics of stimulated emission; Absorption and emission. Emergence of biophysical methods such as CD, Fluorescence spectroscopy, Energy transfer and other such methods from the above principles. Non-linear optics ; Lasers; Pulsed and CW lasers; Multi photon excitation; optical microscopy; diffraction limit; principles of laser scanning microscopes; photo detection; optical microscope in bits and pieces.

Balaji J

None,None,None

NS 302 (JAN) 3:0

Topics in Molecular and Cellular Neuroscience

Cell fate specification, axonal path-finding, signaling in the nervous system, synaptic transmission, learning and memory and neurobiology of psychiatric and neurological disorders.

Balaji J, Narendrakumar Ramanan, Deepak Kumaran Nair

NS202,None,None

NS 301 (JAN) 3:0

Topics in Systems and Cognitive Neuroscience

Sensory encoding, perception and object recognition, attention, decision making. Movement planning, cognitive control.

Aditya Murthy, Arun P Sripati, Supratim Ray, Sridharan Devarajan

NS201,

Division of Chemical Sciences

Preface :

The division of Chemical Sciences comprises of the departments of Inorganic and Physical Chemistry (IPC), Materials Research Centre (MRC), NMR Research Centre (NRC), Organic Chemistry (OC) and Solid State and Structural Chemistry Unit (SSCU). Students with a basic/advanced degree in Chemistry, Physics or several branches of engineering are eligible for admission to the doctoral program in the division. In addition, the division also admits B.Sc. graduates to the Integrated PhD program. Since 2011, the division is also actively engaged in the four-year Bachelor of Science (Research) program and has introduced several courses at the undergraduate level.

The courses offered by various departments carry a two-letter departmental code that is followed by a three digit number; of which, the first digit refers to the course level. In addition, courses offered to the Integrated PhD students are listed separately with another code. The courses offered by the different departments have been grouped as follows:

CD	Integrated Ph D
IP	Inorganic and Physical Chemistry
MR	Materials Research Centre
OC	Organic Chemistry
SS	Solid State and Structural Chemistry

Each department/centre/unit offers courses on several basic as well as specialized topics designed to provide students with a sound foundation in both theoretical and experimental aspects. There are specified requirements for completing the research training programme (RTP) for students registering under different streams at the Institute. For details concerning these requirements, students are advised to approach the department Chairman or the Departmental Curriculum Committee.

The Department of Inorganic and Physical Chemistry provides training in several contemporary areas of theoretical and experimental research covering all aspects of modern Inorganic and Physical Chemistry. The programme of instruction consists of class lectures, laboratory work and student seminars.

The Materials Research Centre provides students opportunity to learn and train on several modern sophisticated instrumental facilities for the materials preparation, device fabrication and materials and device characterization. The Centre offers courses in various aspects of theoretical and experimental Material Science and on modern materials characterization techniques.

The Department of Organic Chemistry offers courses at both the fundamental and advanced levels in Organic Chemistry, in addition to courses on advanced special topics. The students also undergo training in advanced laboratory methods and are expected to give seminars on contemporary research topics.

The Solid State and Structural Chemistry unit offers several courses in frontier areas of Solid State Chemistry and Surface Sciences, besides basic and advanced courses in Chemical Physics; students of the department will have an opportunity to work in all major topics in solid state chemistry and physics.

The NMR Research Centre houses several modern NMR spectrometers; courses are offered at various levels, both on basic and advanced topics. In addition, the center also organizes workshops and symposia in the area of Nuclear Magnetic Resonance. In addition, it provides research facilities in the area of NMR to scientists from all over the country.

Prof. P K Das,
Chairman
Division of Chemical Sciences

Integrated PhD (Chemical Sciences)

Course Work :

Core Courses

I Semester

CD 204 3:0	Chemistry of Materials
CD 211 3:0	Physical Chemistry-I
CD 212 3:0	Inorganic Chemistry
OC 213 3:0	Organic Chemistry
CD 214 3:0	Basic Mathematics
CD 215 0:4	General Chemistry Lab. (Organic & Inorganic)

II Semester

CD 221 3:0	Physical Chemistry II
CD 222 3:0	Material Chemistry
CD 223 3:0	Organic Synthesis
CD 224 2:1	Computers in Chemistry
CD 225 0:4	Physical and Analytical Chemistry Lab

III Semester (optional)
16 Credits of optional courses to be taken from any of the five Departments in consultation with the Ph. D. Supervisor.

IV Semester
CD 241 : 0:14 Research Project Six credits of optional courses in consultation with Ph. D. Supervisor.

CD 402 (AUG) 3:0

Molecular Spectroscopy, Dynamics and Photochemistry

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, RRKMand other statistical theories; photochemistry, quantum yield, photochemical reactions, chemiluminescence,bioluminescence, kinetics and photophysics.

Arunan E

CD 212 (AUG) 3:0

Inorganic Chemistry – Main group and coordination chemistry

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

Jemmis E.D, Abhishake Mondal

Shriver D.F,Atkins P.W. and Langford C.H.,Inorganic Chemistry,Freeman,NY

CD 204 (AUG) 3:0

Chemistry of Materials

Aspects of crystal chemistry (lattices, unit cells, symmetry, point groups and space groups etc), packing, bonding and description of crystal structures, Pauling rules, crystallographic methods, defects in solids, electronic structure, magnetism, phase transitions, framework solids, ionic solids and synthesis of solids

Vasudevan S, Natarajan S

C.N.R. Rao and J. Gopalakrishnan,New directions in solid state chemistry,A.R. West,Solid State Chemistry and its applications,A.F. Wells

CD 211 (AUG) 3:0

Physical Chemistry – I Quantum Chemistry and Group Theory

Postulates of Quantum Mechanics and introduction to operators; Wave Packets, Exactly solvable problems Perturbational, Variational, and WKB Methods; Angular Momentum and Rotations, Hydrogen Atom, Zeeman and Stark effects, Many electron Atoms, Slater determinants, Hartree-Fock Variational Method for atoms; 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

Ramasesha S, Sarma D D

I. Levine,Quantum Chemistry,D. Griffiths,Introduction to Quantum Mechanics.,F. A. Cotton

CD 214 (AUG) 3:0

Basic Mathematics

Differentiation and integration: different methods of evaluating integrals, multi-dimensional integrals, numerical integration. Vectors: gradient, divergence, dash and curl and their physical significance. Matrices: eigen values and eigen vectors. Complex variables: Cauchy-Reimann conditions, Cauchy's theorem, Cauchy's integral formula. Differential equations: differential equations of quantum chemistry and chemical kinetics, numerical solutions of differential equations. The Dirac delta function, the gamma and error function. Function spaces, orthonormal functions, Fourier series, Fourier and Laplace transforms, fast Fourier transforms.

Suryaprakash N, Hanudatta S Atreya

Thomas,G. B.,Finney,R.L.,Calculus and Analytical Geometry

CD 213 (AUG) 3:0

Organic Chemistry – Structure and Reactivity

Stereochemistry and conformational analysis. Methods of deducing organic reaction mechanisms, Hammond postulate, Curtin-Hammett principle, linear free energy relationships; Hammett equation; kinetic isotope effects. Electronic effects in organic compounds, aromaticity, frontier orbital theory, steric effects;organic transformations and molecular rearrangements; reactive intermediates, classical and nonclassical carbocations, carbanions, free radicals, carbenes, nitrenes, arynes, radical ions, diradicals, concerted reactions, Woodward-Hoffman rules.

Uday Maitra, Mrinmoy De

Anslyn,E.V.,and Dougherty,D.A.,Modern Physical Organic Chemistry

CD 215 (AUG) 0:4

Organic & Inorganic Chemistry Laboratory

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 organo-metallic complexes. Physico-chemical characterization of these compounds by analytical and spectroscopic techniques.

Erode N Prabhakaran, Abhishake Mondal

CD 221 (JAN) 3:0

Physical Chemistry II: Statistical Mechanics

Review of thermodynamics, postulates of statistical mechanics, ensembles, classical and quantum statistics. Application to ideal gas, rotational and vibrational problems, black body radiation, electron conduction in metals, specific heats of solids, classical fluids, and phase transitions.

Govardhan P Reddy

E. Fermi, Thermodynamics,H.B. Callen, Thermodynamics and Introduction to Thermostatistics,D.A. MacQuarrie, Statistical Mechanics,D. Chandler, Introduction to Modern Statistical Mechanics

CD 222 (JAN) 3:0

Material Chemistry

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.

Karuna Kar Nanda, 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.,....

CD 223 (JAN) 3:0

Organic synthesis

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.

Jayaraman N, Tushar Kanti 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.

CD 224 (JAN) 2:1

Computers in Chemistry

Basic programming in Python using simple examples. Numerical methods: interpolation, numerical integration and differentiation, Gaussian quadrature, basic linear algebra, eigensolutions, linear and non-linear data fitting, solutions of ODEs.

Sai G Ramesh

Any accessible book on numerical methods.,....,.....

CD 225 (JAN) 0:4

Physical and Analytical Chemistry Laboratory

Langmuir adsorption, chemical analysis bypotentiometry, conductometry and iodometry methods, pH-metry, cyclic voltammetry, flame photometry, electronic states by uv-visible spectroscopy, IR spectroscopy, solid state chemistry – synthesis of solids and chemical analysis, X-ray diffraction.

Sampath S, Aninda Jiban Bhattacharyya

(a) Vogel, A.I, Vogel's text book of quantitative chemical analysis Longman 1989.,(b) David R Shoemaker, Carl W. Garland and Nibler J.W., Experiments in Physical Chemistry, McGraw-Hill International Edition, 1989.,(c) Relevant literature from Chemical Education (ACS Publications) and other pedagogic Chemistry Journals

CD 301 (JAN) 3:0

Advanced NMR Spectroscopy

Basic principles of two-dimensional (2D) NMR spectroscopy, 2D line shapes, phases and filtering. Resolved 2D spectroscopy. Correlated 2D experiments (COSY, TOCSY, etc.) involving homo-nuclear and hetero-nuclear correlations. 2D multiple-quantum spectroscopy, 2D relaxation experiments (NOESY, ROESY). Multinuclear 2D and 3D experiments such as HSQC, HMQC, HNCA and HNCA (CO) etc. Introduction to coherence level diagram, product operator formalism, phase cycling and gradient-enhanced spectroscopy. Two-dimensional NMR of solids. NMR imaging. Applications of two and three-dimensional NMR experiments for structure determination of large molecules.

Suryaprakash N, Hanudatta S Atreya

W. R. Croasmun and R. M. K. Carlson, Two -Dimensional NMR Spectroscopy - Applications for Chemists and Biochemists, VCH, 1987.,.....,.....

CD 241 (JAN) 0:14

Research Project

Aninda Jiban Bhattacharyya

Dept of Inorganic and Physical Chemistry

IP 203 (AUG) 3:0

Group Theory and Molecular Spectroscopy

Group theory: Symmetry elements, point groups, representation theory, great orthogonality theorem, SALCs. Time-dependent perturbation theory, light-matter interaction. H-like atoms, angular momenta and selection rules of transitions, multi-electon atoms, term symbols, spin-orbit coupling, Zeeman and linear Stark effects. Rotations and vibrations of diatoms, anharmonic effects, selection rules, electronic structure. Rotations and vibrations of polyatomic molecules, various tops and their properties, normal modes of vibration, selection rules, electronic states and transitions.

Atanu Bhattacharya

Levine,I,Molecular Spectroscopy Struve,W. S. Fundamentals of molecular spectroscopy Bernath,P. F. Spectra of atoms and molecules (2nd Ed.) Cotton

IP 312 (AUG) 3:0

Advanced Organometallic Chemistry

Structure and bonding in organometallic 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 etc.

Samuelson A G

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

IP 311 (AUG) 3:0

Bio and Medicinal Inorganic Chemistry

Principles of biochemistry and molecular biology, role of metal ions in biology, principles of coordination chemistry, amino acids and other bioligands, proteins – secondary and tertiary structure, nucleic acids, iron proteins, iron transport, role of zinc in biology – zinc enzymes, biological importance of nickel, copper proteins, redox reactions involving manganese, biological roles of vanadium, cobalt and molybdenum, basic concepts in drug design, metals and health - metal-based drugs and mechanism of their action, metalloproteins as drug targets.

Mugesh G

Lippard S.J. and Berg,J.M.,Principles of Bioinorganic Chemistry,University Science Books,California

IP 214 (AUG) 2:1

Crystallography for Chemists

Crystal symmetry. Generation and properties of X-rays. Diffraction theory, reciprocal lattice. Experimental aspects. Rotation, Weissenberg precession and diffractometer techniques. Structure factor equation. Electron density function. Phase problem. Structure solution. Introduction to direct methods. Refinement. Absolute configuration, molecular interactions, solid state reactions. Chemical reaction paths. Electron density studies. Experiments on structure solution related problems. Crystal symmetry. Generation and properties of X-rays. Diffraction theory, reciprocal lattice. Experimental aspects. Rotation, Weissenberg precession and diffractometer techniques. Structure factor equation. Electron density function. Phase problem. Structure solution. Introduction to direct methods. Refinement. Absolute configuration, molecular interactions, solid state reactions. Chemical reaction paths. Electron density studies. Experiments on structure solution related problems.

Nethaji M

Taylor C.A. A nonmathematical introduction to X-ray diffraction. Stout G. and Jensen L.H.,X-ray structures determination. Buerger M.J.,X-ray Crystallography.,-,-

IP 313 (JAN) 3:0

Electrochemical Energy Conversion and Storage

Electrochemical energy systems. Batteries, fuel cells and electrochemical capacitors. Fundamentals and applied aspects. Primary and secondary batteries. Polymer electrolyte membrane fuel cells, solid oxide fuel cells etc. Double layer- and pseudo- capacitors. Integration of electrochemical energy storage systems with other devices.

Sampath S, Prabeer Barpanda

B E Conway, Electrochemical Supercapacitors: Fundamentals and Applications, Kluwer, 1999. C A Vincent and B Scrosati, Modern Batteries, Butterworth-Heinemann 1997. T J Crompton, Battery Reference Book, Elsevier, 2000. Sammes Nigel, Fuel Cell Technology, Springer, 2006.,-,-,-,-

IP 324 (JAN) 3:0

Photophysics and Photochemistry: Fundamentals and Applications

Fundamental concepts in Photophysics and photochemistry, time dependent processes (milli seconds to femtoseconds), excited states, energy transfer, relaxation phenomena, time resolved experimental methods such as absorption, fluorescence, infrared and Raman, examples with applications in chemistry and biology.

Siva Umapathy

N.J.Turro, Modern Molecular Photochemsitry J.N.Demas, Excited State Lifetime Measurements,-,-

IP 322 (JAN) 3:0

Polymer Chemistry

Concepts and terminology. Principles of polymerization – chain versus step growth process. Kinetics of chain polymerization process, estimation of various rate constants. Determination of molecular weight of polymers and their distribution.Solution properties and chain dimension. Characteristics and mechanisms of various chain polymerizations – radical, cationic, anionic, Ziegler-Natta and ring opening metathesis polymerizations. Living polymerizations – criteria for livingness, newer methods for living polymerizations – GTP, ATRP and TEMPO-mediated radical polymerizations. Copolymerization – random, alternating and block copolymers and kinetic schemes for analysis of copolymerization. Micro-structural analysis of polymers by NMR – estimation of regio- and stereo-regularity in polymers, sequence distribution in copolymers etc., and mechanisms for stereo-regulation.

Ramakrishnan S

Flory P.J., Principles of Polymer Chemistry Odian G., Principles of Polymerization. Paul C Hiemenz and Timothy P Lodge, Polymer Chemistry

IP 323 (JAN) 3:0

Topics in Basic and Applied Electrochemistry

Electrode kinetics and electrochemical techniques: polarizable and non-polarizable interfaces; current-potential relationship; methods of measurement of kinetic parameters; over potential; symmetry factor and transfer coefficient; mechanistic criteria; diffusion, activation phenomena. Steady state and potential step techniques; polarography; cyclic voltammetry; chrono- methods; convective diffusion systems: rotating disc and ring disc electrodes; microelectrodes; AC impedance techniques - concepts and applications.Applied topics: fundamentals of batteries: primary, secondary, reserve batteries; solid state and molten solvent-batteries; fuel cells. Photo-electrochemical solar cells and conversion of solar energy. Corrosion – fundamentals and applications.

Sampath S

Bard A.J. and Faulkner L.R., Electrochemical methods: Principles and Applications, Wiley 1990. Greef R., Peat R., Peter L.M., Pletcher D. and Robinson J. (Southampton Electrochemistry Group), Instrumental Methods in Electrochemistry, Ellis Harwood Ltd., 1985. Gileadi E., Electrode Kinetics for Chemists, Chemical Engineers and Material Scientists, VCH 1993. Vincent C.A., Modern Batteries, Edward Arnold, UK 1984. Nozik A.J., Photoeffects at semiconductor-electrolyte interfaces, ACS, Washington 1981.,-,-

IP 314 (JAN) 3:0

Ultrafast Optics and Spectroscopy in Physical Chemistry

Plane wave and phase velocity, Representation of short pulses in time and frequency domain, General construction of laser, Ultrafast Laser System: Oscillator and Amplifier, Gaussian Beam characteristics, Polarization and Birefringence in ultrafast optics, Pulse Measurements in frequency and time domains, Nonlinear Ultrafast Optics: second order, third order, higher order, Dispersion in Ultrafast Optics, Ultrafast Spectroscopy, Ultrafast Dynamics through Conical Intersections, Ultrafast Processes in gas, liquid, and solids.

Atanu Bhattacharya

Ultrafast Optics by Andrew Weiner, Wiley. • Ultrafast Optics Online Book by Rick Trebino (Georgia Institute of Technology) • Modern Optics by Robert Guenther, John Wiley and Sons • Introduction to Modern Optics, Grant R. Fowles, Dover Publications.,-,-,-,-

Materials Research Centre

MR 222 (JAN) 3:0

Chemistry of Materials

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.

Karuna Kar Nanda, Prabeer Barpanda

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

MR 306 (JAN) 3:0

Electron Microscopy in Materials Characterization

Resolution and Rayleigh criterion, electron optics, electron guns and lenses, probe diameter and probe current, electron-specimen interactions, interaction volume. Principles of scanning electron microscopy, imaging modes and detectors. Transmission electron microscopy – elastic and inelastic scattering, modes of operation, diffraction theory, Bragg's law and Laue conditions. Reciprocal space and Ewald sphere construction, Kikuchi lines, convergent beam electron diffraction, diffraction contrast imaging – Howie-Whelan dynamical theory, Thickness and bend contours, imaging defects and strain fields, weak-beam dark field microscopy, phase contrast imaging – Moire fringes, Fresnel fringes and high-resolution imaging.

Ravishankar Narayanan

Goldstein J.I , Romig A.D. Newbury D.E,Goldstein J.I , Romig A.D. Newbury D.E,Goldstein J.I , Romig A.D. Newbury D.E

MR 305 (JAN) 3:0

Functional Dielectrics

Physical and mathematical basis of dielectric polarization, polarization in static/alternating electric fields. Conductivity and loss. piezoelectric, pyroelectric and ferroelectric concepts. Ferroic materials, primary and secondary ferroics, Optical materials. Birefringence and crystal structure, electro-optic materials and light modulators

Balaram Sahoo

Azaroff and Brophy,Electronic processes in Materials,McGraw-Hill,New York 1963,Von Hippel Arthur R

MR 308 (JAN) 2:1

Computational Modeling of Materials

Introduction to computational modeling of materials, description of atomic interaction, tight binding approximation, Hartree-Fock, molecular orbital method, density functional theory. Applications of these methods in modeling of mechanical, electronic, magnetic, optical, and dielectric properties of materials, design principles of novel materials

Abhishek Kumar Singh

Richard Martin.,Electronic Structure: Basic Theory and Practical Methods Cambridge,Richard Martin.,Electronic Structure: Basic Theory and Practical Methods Cambridge,Richard Martin.

MR 307 (JAN) 3:0

Thin Films, Nano Materials and Devices: Science and Engineering

Thin films of functional materials including non-linear dielectrics, III-V and Nitride semiconductors. Processing, structure, and properties of materials at the nanometer length scale. Specific nanofabrication topics include epitaxy, beam lithography, self- assembly, bio-catalytic synthesis, atom optics, and scanning probe lithography. The unique size- dependent properties (electronic, ferroelectric and magnetic) and charge carrier transport in insulating and semiconducting materials and semi-conductor devices. Structure – property correlations with reference to computation, magnetic and ferroelectric storage, sensors and actuators and photo-voltaics

Krupanidhi S B

"Advanced Semiconductors and Organic Nano-Techniques", edited by Morkoc H., Academic Press, 2003,Rainer Waser, Editor., Nanoelectronics and Information Technology, Wiley-VCH Verlag GmbH, Weinheim (2003,Tester, J. W, Drake E. M, Golay M. W, Driscoll M. J., and Peters W. A.. Sustainable Energy - Choosing Among Options.,Cambridge, MA: MIT Press, 2005,Scott J.F., Ferroelectric Memories. Springer. ISBN 3540663878 (2000

MR 302 (JAN) 3:0

Crystal Defects and Properties

Descriptive crystal chemistry for ionic crystals, Pauling's rules, thermodynamics of point defects, point defects in ionic crystals, defect reactions and Kroger-Vink diagrams. Introduction to dislocations, slip, slip systems, perfect and partial dislocations. Thompson tetrahedron and dislocation reactions, planar defects, surfaces and interfaces, direct observation of defects on material. Thermal energy, heat capacity, thermal expansion, thermal conductivity. Negative expansion effects in solids. Thermal shock resistant materials. Thermoelectric effects and materials for thermal energy harvesting.

Arun M Umarji, Bikramjit Basu

Chiang,Y-M.,Birnie IIi,D.P and Kingery W.D.,Physical Ceramics – Principles for Ceramic Science and Engineering

MR 306 (JAN) 3:0

Electron Microscopy in Materials Characterization

Resolution and Rayleigh criterion, electron optics, electron guns and lenses, probe diameter and probe current, electron-specimen interactions, interaction volume. Principles of scanning electron microscopy, imaging modes and detectors. Transmission electron microscopy – elastic and inelastic scattering, modes of operation, diffraction theory, Bragg's law and Laue conditions. Reciprocal space and Ewald sphere construction, Kikuchi lines, convergent beam electron diffraction, diffraction contrast imaging – Howie-Whelan dynamical theory, Thickness and bend contours, imaging defects and strain fields, weak-beam dark field microscopy, phase contrast imaging – Moire fringes, Fresnel fringes and high-resolution imaging.

Ravishankar Narayanan

Goldstein J.I,Romig A.D. Newbury D.E,Goldstein J.I,Romig A.D. Newbury D.E,Goldstein J.I

Organic Chemistry

OC 231 (AUG) 3:0

Chemistry of Proteins and Peptides

Amino acids, peptide synthesis, geometry and oligopeptide conformations. Non-covalent interactions, dynamism in peptides, molecular recognition, Ramachandran plot, Foldamers. Protein architecture, protein-protein interactions, protein stability. Peptide conformational analysis. Protein solubility, pKa, protein aggregates, isofolding, unfolded proteins, membrane proteins. Peptidomimetics, isosteres, folding peptides. Enzymes: mechanisms of selected enzymes, enzyme inhibitors. Important developments in current literature.

Erode N Prabhakaran

Voet D and Voet J.G. Biochemistry 2nd Edition John Wiley Cysons NY,1995.,Stryer L. Biochemistry 4th Edition,WH. Freeman & Co.,NY.

OC 203 (AUG) 3:0

Organic Chemistry-I

Stereochemistry and conformational analysis. Methods of deducing organic reaction mechanisms, Hammond postulate, Curtin-Hammett principle,linear free energy relationships; Hammett equation; kinetic isotope effects. Electronic effects in organic compounds, aromaticity, frontier orbital theory, steric effects;organic transformations and molecular rearrangements; reactive intermediates, classical and nonclassical carbocations, carbanions, free radicals, carbenes, nitrenes, arynes, radical ions, diradicals, concerted reactions, Woodward-Hoffman rules.

Uday Maitra, Mrinmoy De

Anslyn,E.V.,and Dougherty,D.A.,Modern

OC 301 (AUG) 3:0

Organic Synthesis II

Organic synthesis and total synthesis of complex natural products: Advances in C-C bond forming reactions; Olefination reactions; Olefin metathesis including alkyne metathesis; Synthesis of alkynes; Asymmetric addition of Grignard reagents, organozinc and lithium reagents to carbonyl compounds; Directed lithiation, chiral lithium reagents; alkylation of carbonyl compounds including asymmetric alkylation. Addition of organometallinc reagents to imines, Asymmetric acetate/ propionate aldol reaction. Asymmetric allylation of carbonyl compounds; Ring forming reactions, Baldwin rules; cyclopentannulations with specific application to triquinanes. Advances in carbocation rearrangements. Inverse electron demand Diels Alder reaction/ Hetero Diels Alder reaction: Application of the above in the total synthesis of natural products including natural products of contemporary interest in current literature.

Kavirayani R Prasad

Wyatt P. and Warren S,Organic Synthesis,Strategy and Control,; Wiley 2007,Nicolaou

OC 302 (AUG) 3:0

Asymmetric Catalysis: From Fundamentals to Frontiers

Basics of asymmetric catalysis including energetics of reactions; Lewis acid & Lewis base catalysis; Kinetic, Dynamic Kinetic and Parallel Kinetic Resolution; Desymmetrization reactions; Mechanistic studies of asymmetric reactions: nonlinear effects, autocatalysis and autoinduction; Bifunctional, Dual and Multifunctional catalyst systems; Modern aspects of asymmetric catalysis: counterion-directed catalysis, cooperative, dual and merged catalysis, asymmetric photocatalysis etc.; Applications of asymmetric catalysis.

Santanu Mukherjee

Walsh,P.J.,Kozlowski,M.C.,Fundamentals of Asymmetric Catalysis

CD 213 (AUG) 3:0

Organic Chemistry – Structure and Reactivity

Stereochemistry and conformational analysis. Methods of deducing organic reaction mechanisms, Hammond postulate, Curtin-Hammett principle, linear free energy relationships; Hammett equation; kinetic isotope effects. Electronic effects in organic compounds, aromaticity, frontier orbital theory, steric effects;organic transformations and molecular rearrangements; reactive intermediates, classical and nonclassical carbocations, carbanions, free radicals, carbenes, nitrenes, arynes, radical ions, diradicals, concerted reactions, Woodward-Hoffman rules.

Uday Maitra, Mrinmoy De

Carey F.A.,and Sundberg R.J.,Advanced Organic Chemistry,Part A. 5th ed. Plenum,2007~Anslyn

OC 303 (AUG) 3:0

Carbohydrate Chemistry

Structures and conformational itineraries of monosaccharides; Reactions of monosaccharides: reactivity profiles at each carbon center; ring expansions and contractions; reactions at anomeric carbon and epimeric carbons; deoxy sugars; anhydrosugars; protecting group methods; chemical and enzymatic glycosylations to oligosaccharides; glycosidic bond stabilities; naturally-occurring oligo- and polysaccharides and their conformations; chiral auxiliaries and modifications of sugars to carbocycles and heterocycles; aspects of animal and plant polysaccharides, glycoproteins, proteoglycans and glycosaminoglycans; selected natural product synthesis originating from a sugar scaffold

Jayaraman N

References: Monosaccharides: Their chemistry and their roles in natural products,P. Collins and R. Ferrier,John Wiley & Sons Ltd.,Chichester,1998. Carbohydrates: The essential molecules of life

OC 304 (JAN) 3:0

Physical Methods of Structure Elucidation

Structural elucidation of organic compounds using physical methods.Principles underlying the following techniques and their applications inorganic chemistry will be discussed:Infrared, NMR (1H and 13C) Spectroscopy, and Mass Spectrometry; Circular dichroism, 2D NMR spectroscopy

Other physical methods like.

Prabhu K R

Stothers,J.B. Carbon-13 NMR spectroscopy,Vol.XXIV,Academic Press,1972

OC 234 (JAN) 3:0

Organic Synthesis

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

Jayaraman N, Tushar Kanti Chakraborty

Warren S.,Designing Organic Synthesis,1978,Carruthers W. S.,Some Modern Methods of Organic Synthesis 3rd edition

OC 232 (JAN) 3:0

Graduate Colloquium

Students will present a short seminar on a selected contemporary topic which would be extremely useful for educating the students beyond their immediate area of interest. This course will be treated as a departmental requirement for all students registered at the Department of Organic Chemistry during the first year.

Santanu Mukherjee, Mrinmoy De

Solid State and Structural Chemistry

CD 204 (AUG) 3:0

Chemistry of Materials

Aspects of crystal chemistry (lattices, unit cells, symmetry, point groups and space groups etc), packing, bonding and description of crystal structures, Pauling rules, crystallographic methods, defects in solids, electronic structure, magnetism, phase transitions, framework solids, ionic solids and synthesis of solids.

Natarajan S

C.N.R. Rao and J. Gopalakrishnan,New directions in solid state chemistry,A.R. West,Solid State Chemistry and its applications,A.F. Wells

SS 202 (AUG) 3:0

Introductory Quantum Chemistry

Basic postulates of quantum mechanics. Exact solutions: harmonic oscillator (ladder operator approach), particle on a ring and a sphere. Linear operators and matrices. Angular momentum, raising and lowering operators and matrices for spin angular momentum. Hydrogenic atoms (without explicit solution of radial equation), many electron atoms and Slater determinants. Approximate methods - perturbation methods, application to many-electron atoms and term symbols. Variational method - Hartree-Fock method for atoms. Hartree-Fock-Roothan method for molecules. Time-dependent perturbation method - absorption and emission.

Ramasesha S, Anshu Pandey

Ira Levine,Quantum Chemistry,P.W. Atkins,Molecular Quantum Mechanics,A. Szabo and N. Ostlund

SS 205 (AUG) 3:0

Symmetry and Structure in the Solid State

Symmetry, point groups and space groups, crystal lattices. Scattering, diffraction, reciprocal lattice. powder diffraction. Single crystal methods. Data collection and processing synchrotron radiation, phase problem in crystallography. Patterson and direct methods, Rietveld refinement, intermolecular interactions electron density analysis. Basics of neutron diffraction, electron diffraction.

Guru Row T N

C. Giacavazzo (Ed.) Fundamentals of crystallography,J. D. Dunitz,X-ray analysis and the structure of organic molecules,,G.H. Stout and L.H. Jensen

SS 304 (AUG) 3:0

Solar Energy: Advanced Materials and Devices

Important Parameters in Photovoltaics, Shockely-Queisser limit, thermodynamic aspects, photon management. Mechanisms of charge separation and transport: junctions, energy transfer, electron transfer. Advanced Photovoltaic Materials (Perovskite, DSSC, Polymer and Colloidal Nanocrystal), Factors affecting photovoltaic performance-exciton diffusion length, charge transport and band-gap. Organic photovoltaic cells-Schottky, Donor-acceptor, heterojunction and bilayer. Methods of photovoltaic Fabrication and photophysics of molecular sensitizers.

Satish Amrutrao Patil, Anshu Pandey

The Physics of Solar Cell-Jenny Nelson,Imperial College Press,Organic Photovoltaics Mechanisms,Materials and Devices-Niyazi Serdar Sariciftci,Physics of Semiconductor Devices-Sze and Ng.

SS 201 (AUG) 3:0

Thermodynamics and Statistical Mechanics

Formal principles; conditions for equilibrium, Legendre transformation, Maxwell relations. Phase transitions; classification, Landau theory, universality. Irreversible thermodynamics; thermodynamic forces and fluxes. Onsager relations; illustrative applications to electrochemistry; thermo-electric and thermo-magnetic effects. Introduction to far from equilibrium systems. Basic formulations of statistical mechanics; ensembles, partition functions, relations to thermodynamic functions. Ideal systems; quantum statistics, non-ideal gases, Einstein and Debye Solids. Introduction to statistical mechanics of liquids. Computer simulations; basics of Monte Carlo and molecular dynamics techniques.

Govardhan P Reddy

H.B. Callen,Thermodynamics and an Introduction to Thermo Statistics,D.A. Mcquarrie,Introduction to Statistical Mechanics,D. Chandler

CD 211 (AUG) 3:0

Quantum Chemistry and Group Theory

Postulates of Quantum Mechanics and introduction to operators; Wave Packets, Exactly solvable problems Perturbational, Variational, and WKB Methods; Angular Momentum and Rotations, Hydrogen Atom, Zeeman and Stark effects, Many electron Atoms, Slater determinants, Hartree-Fock Variational Method for atoms; 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

Ramasesha S, Sarma D D

SS 303 (JAN) 3:0

Polymeric Materials: Synthesis and Physical Properties

Synthesis of polymers; Reaction Mechanism and Kinetics, Characterization methods; Concepts of soft matter physics and solid-state chemistry relevant to polymers; Specific concepts and physical properties of polymers: chemical structure, morphology, rheology, glass transition; Mechanisms of electron and ion transport; Applications in electrical and optical devices

Satish Amrutrao Patil, Aninda Jiban Bhattacharyya

Handbook of Organic Conductive Molecules and Polymers, H. S. Nalwa, John Wiley & Sons, 2nd Ed, 1997,Solid State Electrochemistry ed. P.G. Bruce, Cambridge University Press, Cambridge, UK, 1995.,Principles of Polymer Chemistry, Paul J. Flory,Kosuke Izutsu, Electrochemistry in Nonaqueous Solutions, Wiley-VCH, Weinheim, 2002.,Solid State Chemistry and its Applications, Anthony R. West, John Wiley and Sons (Asia), Singapore, 2005.

SS 208 (JAN) 3:0

Principles of Solid State Physics

a) Crystal Lattices and Reciprocal Space b) Drude Theory, Sommerfeld Theory, Electrons in a periodic potential c) Free Electron Approximation, Tight Binding Approach, Energy Bands and Dispersion Relations d) Phonon Dispersion and Thermal Transport e) Magnetism f) Superconductivity and Quantum Hall Effect

Ramasesha S, Naga Phani B Aetukuri

Undergrad level Quantum Mechanics and Mathematics,Undergrad level Quantum Mechanics and Mathematics,Undergrad level Quantum Mechanics and Mathematics

Division of Physical and Mathematical Sciences

Preface :

The Division of Physical and Mathematical Sciences comprises the Department of Mathematics, Department of Instrumentation and Applied Physics, Department of Physics, Centre for Cryogenic Technology and Centre for High Energy Physics (formerly Theoretical Studies). The Joint Astronomy and Astrophysics Programme also comes under its purview.

The courses offered in the Division have been grouped into six broad areas. These areas have been identified by code letters as follows:

IN	Instrumentation and Applied Physics
MA	Mathematics
PH	Physics
AA	Astronomy & Astrophysics
HE	High Energy Physics

The course numbers have the prefix of the code letter followed by the numbers. The first digit indicates the level of the course.

There are specific requirements for completing a Research Training Programme for students registering for research conferments at the Institute. For specific individual requirements, the students are advised to approach the Departmental Curriculum Committee.

The Department of Physics and the Centre for High Energy Physics offer an Integrated PhD Programme to which BSc graduates with an adequate background of Physics and Mathematics are admitted.

The Integrated PhD programme in the Mathematical Sciences is offered by the Department of Mathematics to which BSc graduates with an adequate knowledge of Mathematics are admitted.

An M Tech programme in Instrument Technology is offered in the Department of Instrumentation and Applied Physics. For all these programmes, most of the courses are offered by the faculty members of the Division, but in certain special areas, courses offered in other Divisions may also be chosen.

Prof Rahul Pandit
Chairman
Division of Physical &
Mathematical Sciences

Dept of Instrumentation and Applied Physics

M Tech in Instrument Technology
Duration: 2 Years
Credits: 64 credits

	Credits
Core courses	21 credits
Electives	24 credits
Project	19 credits

Core (21 Credits)
18 credits from the pool below + one 3 credit Mathematics course approved by the Department

IN 214 2:1 Semiconductor Devices and Circuits
IN 227 3:0 Control System Design
IN 229 3:0 Advanced Instrumentation and Electronics
IN 244 2:1 Optical Metrology
IN 222 3:0 Microcontrollers and Applications
IN 228 3:0 Automatic System Control Engineering
IN 267 3:0 Fluorescence Microscopy and Imaging
IN 224 3:0 Nanoscience and Device Fabrication
IN 270 3:0 Digital Signal Processing
IN 232 3:0 Concepts in Solid State Physics
IN 302 3:0 Classical and Quantum Optics

Electives: The balance of 24 credits required to make up a minimum of 64 credits for completing the M Tech Programme.

IN 201 3:0 Analytical Instrumentation
IN 212 3:0 Advanced Nano/Micro Systems
IN 210 3:0 Wave propagation in periodic media
IN 223 3:0 Plasma Processes
IN 234 3:0 High Vacuum Technology and Applications
IN 268 2:1 Microfluidic Devices and Applications.
IN 271 3:0 Cryogenic Instrumentation and Applications

Dissertation Project
IN 299 0:19 Disserrtation Project

IN 229 (AUG) 3:0

Advanced Instrumentation Electronics

Instrumentation building blocks: operational amplifiers, RC timers, waveform generators, programmable analog circuits, analog filter design, switched capacitor circuits, CAD for analog circuits. RF circuits: basic transmission line theory, impedance matching, Smith chart, stability of RF amplifiers, VCO, mixer, PLL. Measurement and characterization of noise.

Atanu Kumar Mohanty

Horowitz,P.,and Hill,W.,Art of Electronics

IN 232 (AUG) 3:0

Concepts in solid state physics

Vibrations in solids; Electrons in Metals; Phonons; Tight binding chain; Chemical bonding in solids; Crystal structure; Real and Reciprocal Space; Scattering experiments; Waves in reciprocal space; Band structure and optical properties; Fermi surfaces; Introduction to semiconductors; Magnetism; Practical examples and review.

Chandni U

H. Ibach and H. Luth, Solid State Physics: An Introduction to Principles of Materials Science, Springer, 4th Edition 2009.,Steven H. Simon, The Oxford solid state basics, Oxford University Press, 2013.,Charles Kittel, Introduction to Solid State Physics, Wiley.

IN 210 (AUG) 3:0

Wave propagation in periodic media

Theory of one, two and three dimensional lattices, energy velocity, energy flow, characteristics impedance, Kronig-Penny and tight binding models of crystals, wave propagation in nonlinearstructures. Transmission and reflection of electromagnetic waves on an interface, grating theory, multi-dimensional phononic and photonic crystals, materials and techniques of fabrication, nature inspired periodic structures, device applications

Abha Misra

C. Kittel,Introduction to Solid State Physics,John Wiley & Sons 1953.,A. P. French,Vibrations and WavesW. W. Norton & company 1971.

IN 201 (AUG) 3:0

Analytical Instrumentation

Principles, instrumentation, design and application of UV, visible and IR spectroscopy, mass spectrometry, Mossbauer and NMR spectroscopy, X-ray methods of analysis including powder diffraction, wavelength and energy dispersive x-ray fluorescence. Electron microscopy and microprobe. ESCA and AUGer techniques, photo electron spectroscopic methods, scanning tunneling and atomic force microscopy. Chromatography, thermal analysis including DTA, DSC and TGA. Thermal wave spectroscopic techniques such as photo-acoustic, photo-thermal deflection and photopyro-electric methods.

Asokan S, Siva Umapathy

Willard,H.W.,Merritt,L.L.,Dean

IN 270 (AUG) 3:0

Digital Signal Processing

Fourier analysis, Fourier Integral, Discrete Fourier transform multiplications of two signals, Z transform, convolution, correlation Digital filtering, Discrete transformation modulation, FIR, IIR filters, Analog I/O interphase for real time DSP system, application of TMS320 C6713DSK to evaluate convolution, IIR and FIR filter.

Mondal T K

Ervin Kreszic - Advanced engineering mathematics,Robert F Coughlin.,Frederick F driscoll,opreational amplifier and linear integrated circuits.,Emmanual c Ifeachar

IN 267 (AUG) 3:0

Fluorescence Microscopy and Imaging

Light Sources, Monochromators, Optical Filters, Photomultiplier tubes, polarizers, Beer-Lambart Law, Paraxial ray Optics and System Designing, Wave Optics, electromagnetic theory, fluorescence microscopy systems, molecular physics, photo-physics and Stern-Volmer equation, Jablonski diagram, emission spectra, fluorescence lifetime and quantum yield, time-domain lifetime measurements, fluorescence correlation spectroscopy, total internal reflection fluorescence microscopy, electric field effects, point spread function, single-and multi-photon fluorescence microscopy, advanced super resolution microscopy, aperture engineering techniques, 3D image reconstruction, Markov random field, maximum likelihood algorithm, Bayes theorem.

Partha Pratim Mondal

Prerequisites: Knowledge of C and MATLAB Programming.,James Pawley,Handbook of Biological Confocal Microscopy,Springer,Springer Science + Business Media

IN 228 (JAN) 3:0

Automatic System Control Engineering

Digital interfacing, A/D conversion by 8 bit, 12 bit and 16 bit, system calibration, compensation. Application of proportional control and PID control to systems and comparison, case studies. Stability analysis and performance modeling. Advantages of microcomputer based industrial process control systems. Remote control methods. Introduction of fuzzy logic and Application. Linux infrared remote control.

Mondal T K

Hall,D.V.,Microprocessors and interfacing,McGraw Hill,1986.

IN 268 (JAN) 2:1

Microfluidic Devices and Applications

Basic principles in microfluidics, design principles for microfluidic devices, device fabrication techniques, components of microfluidic devices (micro-pump, mixers, lenses, valves, heaters, sensors, etc.), utility of microfluidic devices in various biological, chemical and optical sensing applications, opto-fluidics, Inertial-microfluidics, droplet-microfluidics, microfluidics based-flow cytometry. This course also provides hands on-experience in the design, fabrication and characterization of Lab-on-chips or point-of care testing devices.

Sai Siva Gorthi

Introduction to Microfluidics by Patric tabeling. 2005,Wereley,Biological Applications of Microfluidics edited by Frank A. Gomez,2006,Fundamentals and Applications of Micro-fluidicsBy Nam-Trung nguyen and Stev

IN 227 (JAN) 3:0

Control Systems Design

Dynamics of linear systems, Laplace transforms, analysis of feedback control systems using Nyquist plots, Bode plots and Root Locus, design of control systems in single-degree of-freedom configuration using direct design, proportional-integral-derivative control, lead-lag ompensation, design of control systems in two-degree of-freedom configuration to achieve robustness, Quantitative feedback theory control of non-minimum phase systems, Bode sensitivity integrals, use of describing functions to analyze and compensate nonlinearities.

Jayanth G R

Horowitz I.M.,Synthesis of Feedback Systems,Academic Press,1963.,Goodwin G. C.

IN 223 (JAN) 3:0

Plasma Processes

Glow discharge plasmas, ion surface interactions, magnetron discharges, ion sources, DC, RF and ECR plasmas, surface modification using ion sources, ion beam mixing and ion implantation, ion beam etching for microelectronic devices, plasma diagnostics, Langmuir probe, glow discharge mass spectrometry and optical emission spectrometry, plasma surface modification.

Mohan Rao G

Chapman,B.N.,Glow Discharge Processes,John Wiely and Sons,1979.

IN 271 (JAN) 3:0

Cryogenic Instrumentation and Applications

Introduction and fundamentals of cryogenic technology, Properties of cryogenic fluids, Properties of materials at low temperatures, Cryogenic refrigeration systems and gas liquefaction systems, Measurement of temperature, pressure, flow and liquid level, Cryogenic fluid storage and transfer systems, Design of cryostats and cryogenic systems, Cryocoolers, Cryogenic safety, Applications of cryogenics.

Upendra Behera

Randall F. Barron,Cryogenic Systems,Second Edition,Oxford University Press,1985.

IN 214 (JAN) 3:0

Semiconductor Devices and Circuits

Quantum Mechanics Fundamentals, Schrodinger Equation, Particle ina Box, Harmonic Oscillator, Bonding, Crystals, Winger Seitz Cell, Bragg?s Law, Lattice Waves and Phonons, Reciprocal Lattice Brillouin Zones, Kronig Penny Model, Formation of Energy Bands, Metals, Semiconductors- Density of States, Fermi Function, Carrier Concentrations and Mass Action Law, Doping, Recombination and Generation, Continuity Equation, Metal Semiconductor Junctions, PN Junctions, BJT, JFET, MESFET, MOS Capacitor, MOSFETs, Small Signal Models, Single Stage Amplifiers Basics, Organic Semiconductors, amorphous silicon, metal oxides.

Sanjiv Sambandan

Advanced Semiconductor Fundamentals,Robert F Pierret,Modular series on Solid State Devices,Robert F Pierret and Gerold W Neudeck Pearson Education Inc,Semiconductor Devices: Physics and Technology

IN 212 (JAN) 3:0

Advanced Nano/Micro Systems

Fundamentals of MEMS & NEMS fabrication, Physical properties of MEMS and NEMS devices, doping, pattern generation, tools for nanoscale characterizations, CMOS based devices, Advanced sensing systems such as image sensor, touch sensors, accelerometer, gyroscope, flow sensors, actuators, transducers, thermal sensor, electrostatic, piezoelectric piezoreristive sensors, chemical sensors, biological sensors, strain gauges, load cells, pressure sensors, optical sensors, signal conditioning circuits for sensors, control units etc., electrons and ions optics, single electron tunneling, quantization of electrical conduction, electronic and photonic band gap crystals.

Abha Misra

M. J. Madou,Fundamentals of microfabrication,CRC Press 1997.,H. J,Levinson

IN 222 (JAN) 3:0

Microcontrollers and Applications

Architecture of Microcontrollers and hardware interfacing techniques. Introduction to Integrated development environment for application software development. A/D – D/A interfaces. Stepper and DC Motor controls. Finite state Machine Models for applications. Case studies of applications controlled via local keyboard or by using serial Interfaces. Use of I2C bus in applications.

Ramgopal S

Ayala,The 8051 Microcontroller,Third Edn,Thomson,2007. Mazidi

IN 224 (JAN) 3:0

Nanoscience and Device fabrication

Nanoscience: Introduction, classification, Summary of electronic properties of atoms and solids, Effects of the nanometer length scale, General methodologies for nanomaterial characterization, semiconductor physics - semiconductor nanostructures, Quantum confinement in semiconductor nanostructures, Modulation doping, Interband/Intraband absorption in semiconductor nanostructures, Phonon bottleneck, thermodynamics and kinetics of phase transformations, Applications of semiconductor nanostructures Device fabrication: Growth techniques and properties, thin film phenomena, PVD and CVD techniques, MBE-growth of self assembled InAs quantum dots, Heterostructures grown inside MBE, FIB for ion implantation and insulation writing, lithography.

Asha Bhardwaj

Fundamentals of Nanoelectronics by George W. Hanson~Nanotechnology-understanding small systems by Ben Rogers, Jesse Adams, Sumita Pennathur~Nanotechnology:Principles and practices by Sulabha Kulkarni

IN 299 (JAN) 0:19

Dissertation Project

IN 266 (JAN) 3:0

Introduction to Quantum Measurement and Control

Introduction to Classical Measurement, Introduction to quantum mechanics through measurement, the quantum measurement postulate and its consequences, standard quantum limits (SQL), types of measurements – direct and indirect measurements, orthogonal, non-orthogonal, quantum non-demolition measurements, linear measurements and amplification, beyond the SQL - parametric amplification. Case studies of measurement – quantized charge measurement, single photon detection, non-demolition method for photon, quadrature measurements etc. Control of single quantum systems, introduction to decoherence – decoherence as measurement by environment, characterizing decoherence in qubits, openloop control and stabilization of qubit states.

Vladimir B. Braginsky and Farid Ya. Khalili,“Quantum Measurement”,Cambridge University Press,1995,Howard M. Wiseman

Dept of Mathematics

Course No. Credits Course title
Core Courses (these are compulsory)

ESSENTIAL COURSES

Course No.	**Credits Course Title**
MA 212 3:0	Algebra I
MA 219 3:1	Linear algebra
MA 221 3:0	Analysis I
MA 223 3:0	Functional analysis
MA 231 3:1	Topology I
MA 242 3:0	Partial differential equations
MA 261 3:0	Probability models
MA 232 3:0	Introduction to algebraic topology
MA 361 3:0	Probability theory
MA 220 3.0	Representation theory
MA 200 3.0	Multivariable Calculus

ELECTIVES COURSES

Course No.	Credits Course Title
MA 338 3:0	Differential manifolds & Lie Group
MA 360 3:0	Random Martix theory
MA 312 3.0	Commutative Algebra

MA 220 (AUG) 3:0

Representation theory of Finite groups

Representation of finite groups, irreducible representations, complete reducibility, Schur's lemma, characters, orthogonality, class functions, regular representations and induced representation, the group algebra.

Linear groups: Representation of the group SU2

Books

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

Fulton W., and Harris, J., Representation Theory, Spinger-Verlag, 1991.

Serre, J. P., Linear Representations of Finite Groups, Springer-Verlag, 1977.

Venkatesh R, Apoorva Khare

MA 219,MA 212,Etingof Pavel. Golberg Oleg. Hensel Sebastian. Liu Tiankai. Schwendner Alex. Vaintrob Dmitry. Yudovina Elena. Introduction to representation theory. With historical interludes by Slava Gerovitch. Student Mathematical Library 59. American Mathematical Society. 2011.,Linear representations of finite groups. J. P. Serre. Graduate Texts in Mathematics. Vol. 42. Springer-Verlag. New York-Heidelberg. 1977.

MA 223 (AUG) 3:0

Functional Analysis

Basic topological concepts, Metric spaces, Normed linear spaces, Banach spaces, Bounded linear functionals and dual spaces, Hahn-Banach Theorem, Bounded linear operators, Open mapping theorem, Closed graph theorem, Banach-Steinhaus theorem, Hilbert spaces, Riesz Representation Theorem, Orthonormal sets, Orthogonal complements, Bounded operators on a Hilbert space up to (and including) the spectral theorem for compact, self–adjoint operators.

Bhattacharyya T

MA 222,MA 224,MA 219,John Conway A Course in Functional Analysis (Springer),Rajendra Bhatia Notes On Functional Analysis Texts and Readings in Mathematics (Hindustan Book Agency 2009)

MA 361 (AUG) 3:0

Probability theory

Probability measures and random variables, pi and lambda systems, expectation, the moment generating function, the characteristic function, laws of large numbers, limit theorems, conditional contribution and expectation, martingales, infinitely divisible laws and stable laws.

Srikanth Krishnan Iyer

Probability Theory and Examples Durrett,Probability Shiryayev,MA222 Measure Theory

MA 212 (AUG) 3:0

Algebra I

Part A 1. Groups: definitions & basic examples; 2. Normal subgroups, quotients; 3. Three isomorphism theorems; 4. Centralizer and normalizer of a subset, centre of a group; 5. Permutations, symmetric groups and Cayley's Theorem; 6. Group actions and their applications, Sylow's theorems. Part B 1. Rings and ideals: basic definitions, quotient rings; 2. The Chinese Remainder Theorem; 3. Maximal and prime ideals; 4. Unique factorization, unique factorization domains, principal ideal domains, Euclidean domains, polynomial rings; 5. Modules: basic definitions and examples, Hom and tensor products, the Structure Theorem for finitely generated modules over PIDs; 6. Fields: basic definitions and examples, algebraic & transcendental numbers; 7. Finite fields, characteristic, the order of a finite field.

Pooja Singla

UM 203,Artin M. Algebra. Prentice-Hall of India. 1994.,Dummit. D. S. and Foote R. M. Abstract Algebra. McGraw-Hill. 1986.,Herstein I. N. Topics in Algebra. John Wiley and Sons. 1995.,Lang S. Algebra. (3rd Ed.) Springer. 2002.

MA 219 (AUG) 3:1

Linear algebra

Vector spaces: definition, basis and dimension, direct sums. Linear transformations: definition, the Rank-Nullity Theorem, the algebra of linear transformations. Dual spaces. Matrices. Systems of linear equations: elementary theory of determinants, Cramer's rule. Eigenvalues and eigenvectors, the characteristic polynomial, the Cayley-Hamilton Theorem, the minimal polynomial, algebraic and geometric multiplicities. Diagonalization. The Jordan canonical form. Symmetry: group of motions of the plane, discrete groups of motion, finite subgroups of SO(3). Bilinear forms: symmetric, skew-symmetric and Hermitian forms, Sylvester's law of inertia, Spectral theorem for Hermitian and normal operators on finite-dimensional vector spaces.

Venkatesh R

UM 102,Hoffman K. and Kunze R. Linear Algebra (2nd Ed.) Prentice-Hall of India. 1992.,Artin M. Algebra. Prentice-Hall of India. 1994.,Halmos P. Finite dimensional vector spaces. Springer-Verlag (UTM). 1987.

MA 231 (AUG) 3:1

Topology

Point-set topology: Open and closed sets, Continuous functions, Metric topology, Product topology, Connectedness and path-connectedness, Compactness, Countability axioms, Separation axioms, Complete metric spaces, Quotient topology, Topological groups, Orbit spaces. The fundamental group: Homotopic maps, Construction of the fundamental group, Fundamental group of the circle, Homotopy type, Brouwer's fixed-point theorem, Separation of the plane.

Harish Seshadri

MA 200 (AUG) 3:1

Multivariable Calculas

Functions on Rn, directional derivatives, total derivative, higher order derivatives and Taylor series. The inverse and implicit function theorem, integration on Rn, differential forms on Rn, closed and exact forms. Green's theorem, Stokes' theorem and the Divergence theorem.

Kaushal Verma

MA 232 (AUG) 3:0

Introduction to Algebraic Topology

Basudeb Datta

MA 231~MA212

MA 261 (AUG) 3:0

Probability Models

Sample spaces, events, probability, discrete and continuous random variables, Conditioning and independence, Bayes formula, moments and moment generating function, characteristic function, laws of large numbers, central limit theorem, Markov chains, Poisson processes.

Siddhartha Gadgil

Ross,S.M.,Introduction to Probability Models,Academic Press 1993.,Taylor

MA 221 (AUG) 3:0

Analysis I

Construction of the field of real numbers and the least upper-bound property. Review of sets, countable & uncountable sets. Metric Spaces: topological properties, the topology of Euclidean space. Sequences and series. Continuity: definition and basic theorems, uniform continuity, the Intermediate Value Theorem. Differentiability on the real line: definition, the Mean Value Theorem. The Riemann-Stieltjes integral: definition and examples, the Fundamental Theorem of Calculus. Sequences and series of functions, uniform convergence, the Weierstrass Approximation Theorem. Differentiability in higher dimensions: motivations, the total derivative, and basic theorems. Partial derivatives, characterization of continuously-differentiable functions. The Inverse and Implicit Function Theorems. Higher-order derivatives.

Gautam Bharali

Rudin W. Principles of Mathematical Analysis. 3rd edition. McGraw-Hill International Edition.,Tao T. Analysis I. 3rd edition. TRIM series. Hindustan Book Agency. 2014.,Tao T. Analysis II. 3rd edition. TRIM series. Hindustan Book Agency. 2014.,Apostol T. M. Mathematical Analysis. Narosa. 1987.

MA 242 (AUG) 3:0

Partial Differential Equations

Nandakumaran A K

MA241,Fritz John,Folland

MA 370 (AUG) 3:0

Hermitian Analysis

Hilbert spaces: Polarization compact Hermitian operators, Sturm – Liouville Theory Spherical Harmonics

Inequalities: The isoperimetric inequalities Vector fields and differential forms volume computations Positivity conditions for hermitian polynomials

Gadadhar Misra

,John D'Angelo. Hermitian Analysis: From Fourier Series to Cauchy-Riemann Geometry~~~~

MA 266 (AUG) 3:0

Stochastic Finance - I

Financial market. Financial instruments: bonds, stocks, derivatives. Binomial no-arbitrage pricing model: single period and multi-period models. Martingale methods for pricing. American options: the Snell envelope. Interest rate dependent assets: binomial models for interest rates, fixed income derivatives, forward measure and future. Investment portfolio: Markovitz's diversification. Capital asset pricing model (CAPM). Utility theory.

Mrinal Kanti Ghosh

Luenberger D.V. Investment Science. Oxford University Press. 1998.,Shiryaev A.N. Essentials of Stochastic Finance. World Scientific. 1999.,Shreve S.E. Stochastic Calculus for Finance I: The Binomial Asset pricing Model. Springer. 2005.

MA 335 (AUG) 3:0

Introduction to Hyperbolic Manifolds

This is an introduction to hyperbolic surfaces and 3-manifolds, which played a key role in the development of geometric topology in the preceding few decades. Topics that shall be discussed will be from the following list: Basic notions of Riemannian geometry, Models of hyperbolic space, Fuchsian groups, Thick-thin decomposition, Teichmüller space, The Nielsen Realisation problem, Kleinian groups, The boundary at infinity, Mostow rigidity theorem, 3-manifold topology and the JSJ-decomposition, Statement of Thurston's Geometrization Conjecture (proved by Perelman)

Subhojoy Gupta

MA231,MA232 or equivalent,Martelli - Introduction to Geometric Topology

MA 310 (AUG) 3:0

Algebraic Geometry I

Refresher on Commutative Algebra: localization, local rings, integral closure, Krull dimension.Zariski topology, Hochster's characterization of Zariski topology, spectral spaces. Zariski spectrum as a frame Refresher on categories : Categories, functors, Yoneda Lemma, equivalence of categories, adjoints.Grothendieck sites : Zariski, '{e}tale and Nisnevich sites. Presheaves and Sheaves Locally ringed spaces and schemes Separated schemes, proper schemes, irreducible schemes, reduced schemes, integral schemes, noetherian schemes. Morphisms : separated, proper, finite morphisms, finite type morphisms, affine morphisms Sheaves of algebras : affine morphisms as sheaves of algebras Sheaves of modules over a scheme, Quasi-coherent and coherent sheaves Divisors and Line Bundles, Weil divisors, Cartier divisors, Line bundles on Projective spaces, Serre sheaves. Projective morphisms, ample and very ample line bundles Formal schemes

Abhishek Banerjee

MA 212,Robin Hartshorne. Algebraic geometry. Graduate Texts in Mathematics. No. 52. Springer-Verlag. New York-Heidelberg. 1977.,Robin Hartshorne. Residues and duality Lecture notes of a seminar on the work of A. Grothendieck given at Harvard 1963/64. With an appendix by P. Deligne. Lecture Notes in Mathematics. No. 20 Springer-Verlag Berlin-New York 1966.

MA 399 (AUG) 2:0

Seminar on topics in Mathematics

Vamsi Pritham Pingali

MA 210 (JAN) 3:0

Logic, Types and Spaces

This course is an introduction to logic and foundations from both a modern point of view (based on type theory and its relations to topology) as well as in the traditional formulation based on first-order logic.

Topics:

Basic type theory: terms and types, function types, dependent types, inductive types. First order logic: First order languages, deduction and truth, Models, Godel's completeness and compactness theorems. Godel's incompleteness theorem Homotopy Type Theory: propositions as types, the identity type family, topological view of the identity type, foundations of homotopy type theory. Most of the material will be developed using the dependently typed language/proof assistant Agda. Connections with programming in functional languages will be explored.

Siddhartha Gadgil

No prior knowledge of logic is assumed. Some background in algebra and topology will be assumed. It will be useful to have some familiarity with programming.~Homotopy Type Theory: Univalent Foundations of Mathematics .Institute for Advanced Studies. Princeton 2013; available at http://homotopytypetheory.org/book/~Manin Yu. I. A Course in Mathematical Logic for Mathematicians. Second Edition .Graduate Texts in Mathematics. Springer-Verlag. 2010.~Srivastava S. M.. A Course on Mathematical Logic. Universitext. Springer-Verlag. 2008 .~

MA 311 (JAN) 3:0

Algebraic Geometry II

Sheaves of differentials. Background on homological algebra : resolutions, derived functors, d -categories. Triangulated categories, Derived categories of abelian categories. Injective and flasque resolutions. Cohomology of sheaves of abelian groups Vanishing theorems for cohomology Serre's criterion for affineness \v{C}ech cohomology Cohomology of projective space, twisting by Serre sheaves Ext andTor for sheaves Serre duality theorem Schemes as functors of points, the idea of stacks

Abhishek Banerjee

~Robin Hartshorne. Algebraic geometry. Graduate Texts in Mathematics. No. 52. Springer-Verlag. New York-Heidelberg. 1977.~Robin Hartshorne. Residues and duality. Lecture notes of a seminar on the work of A.~Grothendieck. given at Harvard 1963/64. With an appendix by P. Deligne. Lecture Notes in Mathematics. No. 20 Springer-Verlag. Berlin-New York 1966.~~

MA 384 (JAN) 3:0

Mathematical Physics

Kaushal Verma

MA 385 (JAN) 3:0

Classical groups

General and special linear groups, bilinear forms, Symplectic groups, symmetric forms, quadratic forms, Orthogonal geometry, orthogonal groups, Clifford algebras, Hermitian forms, Unitary spaces, Unitary groups.

Pooja Singla

MA 212~MA 219~L. C. Grove. Classical Groups and Geometric Algebra. Graduate Studies in Mathematics 39. American Mathematical Society. 2002.~A. Artin. Geometric Algebra. John Wiley & sons. 1988.~Herman Weyl. The Classical Groups. Princeton University Press. Princeton. 1946.

MA 366 (JAN) 3:0

Stochastic Finance II

Trading in continuous time : geometric Brownian motion model. Option pricing : Black-Scholes-Merton theory. Hedging in continuous time : the Greeks. American options. Exotic options. Market imperfections. Term-structure models. Vasicek, Hull-White and CIR models. HJM model. LIBOR model. Introduction to credit Rsik Models: structural and intensity models. Credit derivatives.

Mrinal Kanti Ghosh

~Amman M. Credit Risk Valuation. Second Edition. Springer. 2001.~Brigo D and Mercurio. F. Interest Rate Models Theory and Practice. Second Edition .Springer. 2007 .~Shiryaev A.N. Essentials of Stochastic Finance. World Scientific. 1999.~Shreve S.E. Stochastic Calculus for Finance II : The continous Time Models. Springer. 2004.

MA 319 (JAN) 3:0

Algebraic Combinatorics

The algebra of symmetric functions, Schur functions, RSK algorithm, Murnaghan- Nakayama Rule, Hillman-Grassl correspondence, Knuth equivalence, jeu de taquim, promotion and evacuation, Littlewood-Richardson rules.No prior knowledge of combinatorics is expected, but a familiarity with linear algebra and finite groups will be assumed.

Arvind Ayyer

Stanley R. Enumerative Combinatorics. volume 2. Cambridge University Press. 2001.~Sagan B. The Symmetric Group: Representations. Combinatorial Algorithms. and Symmetric Functions. Graduate Texts in Mathematics vol. 203. Springer-Verlag. 2001.~Prasad A. Representation Theory : A Combinational Viewpoint. Cambridge Studies in Advanced Mathematics vol. 147. 2014.~Stanley R. Lecture notes on Topics in Algebraic Combinatorics.~

MA 241 (JAN) 3:1

Ordinary Differential Equations

Basics concepts:Introduction and examples through physical models, First and second order equations, general and particular solutions, linear and nonlinear systems, linear independence, solution techniques. Existence and Uniqueness Theorems :Peano’s and Picard’s theorems, Grownwall’s inequality, Dependence on initial conditions and associated flows. Linear system:The fundamental matrix, stability of equilibrium points, Phase- plane analysis, Sturm-Liouvile theory . Nonlinear system and their stability:Lyapunov’s method, Non-linear Perturbation of linear systems, Periodic solutions and Poincare- Bendixson theorem

Thirupathi Gudi

221,Coddington, E. A. and Levinson, N., Theory of Ordinary Differential Equations ,Tata McGraw-Hill, 1972,Perko, L., Differential Equations and Dynamical Systems ,Springer-Verlag, 1991.

MA 278 (JAN) 3:0

Introduction to Dynamical Systems Theory

Linear Stability analysis, attracters, limit cycles, Poincare-Bendixson theorem, relaxation oscillations.Elements of Bifurcation theory, saddle-node, transcritical, pitchfork and Hopf bifurcations. Integrability, Hamiltonian systems, Lotka-Volterra equations. Lyapunov functions and dirct methods for stability, dissipative systems, Lorenz systems, chaos and its measures, Lyapunov exponents, strange attractors, simple maps, period-doubling bifurcations, Feigenbaum constants, fractals.

MA 315 (JAN) 3:0

Lie Algebra and their representation

Finite dimensional Lie algebras, Ideals, Homomorphisms, Solvable and Nilpotent Lie algebras, Semisimple Lie algebras, Jordan decomposition, Kiling form, root space decomposition, root systems, classification of complex semisimple Lie algebras Representations Complete reducibility, weight spaces, Weyl character formula, Kostant, steinberg and Freudenthal formulas

Books

J E Humphreys Introduction to Lie algebras and Representation theory Springer-Verlag, 1972.
J P Serre Complex Semisimple Lie Algebras, Springer, 2001 Fulton. W., and Harris J. Representation theory, Springer-Verlag. 1991.

Venkatesh R

none,none,none

MA 213 (JAN) 3:1

Algebra II

Part A 1. Introduction to categories and functors, direct and inverse limits; 2. Field of fractions of an integral domain, localization of rings; 3. i-adic completion of rings; 4. Tensor products, short exact sequences of modules; 5. Noetherian rings and modules, Hilbert Basis Theorem, Jordan-Holder Theorem; 6. Artinian rings, Artinian implies Noetherian, Krull-Schmidt Theorem. Part B 1. Splitting fields, normal and separable extensions; 2. Application to finite fields; 3. The Fundamental Theorem of Galois Theory; 4. The Primitive Element Theorem.

Soumya Das

MA 212~Artin M. Algebra. Prentice Hall of India. 1994.~Dummit D. S. and Foote. R. M.. Abstract Algebra .McGraw-Hill. 1986.~Lang S. Algebra (3rd Ed.) .Springer. 2002.~Atiyah M. and MacDonald. R. Introduction to Commutative Algebra .Addison-Wesley(or any reprint).

MA 392 (JAN) 3:0

Random Graphs and interacting particle systems

rdos - Renyi random graphs, graphs with power law degree distributions, Ising Potts and contact process, voter model, epidemic models. Books Bollobas Bela, Random graphs, Cambridge University Press, Second Edition, 2006. Janson, S., Luczak, T and Rucinski, A, Random Graphs, Wiley, 2000. Durrct, R: Random Graph Dynamics, Cambridge, 2011.

Srikanth Krishnan Iyer

none,none,none

MA 222 (JAN) 3:1

Analysis II

Sigma-algebras, outer measures and measures. Construction of Lebesgue measure. Measurable functions. Lebesgue integration and integration with abstract measures. Monotone convergence theorem, Fatou's lemma and the dominated convergence theorem. Comparison of Riemann integration and Lebesgue integration. Product sigma-algebras, product measures, Fubini's theorem. Signed measures and the Radon-Nikodym theorem. L^p spaces, characterization of continuous linear functionals on L^p spaces. Complex measures, the Riesz representation theorem.

Narayanan E K

MA 221~Stein E. M. and Shakarchi R. Real analysis: measure theory. integration and Hilbert spaces. Princeton university press (2005).~Folland G.B. Real Analysis: Modern Techniques and their Applications (2nd Ed.) .Wiley.~Royden H. L. Real Analysis .Macmillan. 1988.~Hewitt E. and Stromberg. K. Real and Abstract Analysis. Springer. 1969.

MA 224 (JAN) 3:1

Complex Analysis

Complex numbers, complex-analytic functions, and the Cauchy-Riemann condition. Cauchy's integral integral formula, power series. Liouville's theorem and applications. The maximum-modulus principle. Morera's theorem, Schwartz reflection principle. Isolated singularities and the residue theorem. Contour integration. Möbius transformations, conformal mappings. Normal families and Montel's theorem. The Riemann Mapping Theorem. The Schwarz Lemma: proof, applications, automorphisms of the unit disc. Basics of analytic continuation (time permitting).

Thangavelu S

MA 221~Stein E. M. and Shakarchi R. Complex analysis. Princeton university press (2003).~Ahlfors L. V. Complex Analysis. McGraw-Hill. 1979.~Conway J. B. Functions of One Complex Variable. Springer-veriag. 1978.~

MA 229 (JAN) 3:0

Calculus on manifolds

Basics: The inverse function and implicit function theorems. The Riemann integral in higher dimensions, partitions of unity, the change of variables formula. Stokes' Theorem: Introductory multilinear algebra, differential forms, the exterior derivative. Integration of differential forms, differentiable simplices and chains, Stokes' Theorem for differentiable chains. Stokes' Theorem for embedded submanifolds in Euclidean space: motivations and statement, examples and special cases. Differentiable manifolds: Definitions and examples. Smooth functions on manifolds. The tangent bundle. Immersions, embeddings and submersions. The implicit function theorem on manifolds.

Subhojoy Gupta

MA 221~Spivak. M. Calculus on Manifolds. W.A. Benjamin. co. 1965.~Hirsh. M.W. Differential Topology. Springer-Verlag. 1997.~~

MA 340 (JAN) 3:0

Advanced functional Analysis

Banach algebras, Gelfand theory, C* - algebras the GNSconstruction, spectral theorem for normal operators, Fredholm operators. The L- infinity functional calculus for normal operators.

Bhattacharyya T

MA 223~Conway J.B. A Course in Functional Analysis. Springer. 1985.~Douglas R. G. Banach Algebra Techniques in Operator Theory. Academic Press. 1972.~~

MA 339 (JAN) 3:0

Geometric Analysis

Basics of Riemannian geometry (Metrics, Levi-Civita connection, curvature, Geodesics, Normal coordinates, Riemannian Volume form), The Laplace equation on compact manifolds (Existence, Uniqueness, Sobolev spaces, Schauder estimates), Hodge theory, more general elliptic equations (Fredholmness etc), Uniformization theorem.
Suggested books :

Do Carmo, Riemannian Geometry.
Griffiths and Harris, Principles of Algebraic Geometry.
S. Donaldson, Lecture Notes for TCC Course “Geometric Analysis”.
J. Kazdan, Applications of Partial Differential Equations To Problems in Geometry.
L. Nicolaescu, Lectures on the Geometry of Manifolds.
T. Aubin, Some nonlinear problems in geometry.
C. Evans, Partial differential equations.
Gilbarg and Trudinger, Elliptic partial differential equations of the second order.
G. Szekelyhidi, Extremal Kahler metrics.

Vamsi Pritham Pingali

MA 386 (JAN) 3:0

Coxeter Groups

Reflection groups and their generalisations, Coxeter systems, permutation representations, reduced words, Bruhat order, Kazhdan-Lusztig theory, Chevalley's theorem, Poincare series, root systems, classification of finite and affine Coxeter groups No prior knowledge of combinatorics or algebra is expected, but we will assume a familiarity with linear algebra and basics of group theory. Suggested books : Anders Bjorner & Francesco Brenti, Combinatorics of Coxeter Groups, Springer GTM, 2005. James E. Humphreys, Reflection Groups and Coxeter Groups, Cambridge University Press, 1990. Michael W. Davis, The Geometry and Topology of Coxeter Groups, Princeton University Press, 2008. Nicolas Bourbaki, Elements Of Mathematics: Lie Groups and Lie Algebras: Chapters 4-6, Springer 2002.Top

Arvind Ayyer

MA 326 (JAN) 3:0

Fourier Analysis

Narayanan E K

MA 223~Dym H. and Mckean. H.P. Fourier Series and Integrals. 1972.~Stein E.M. Singular Integrals and Differentiability Properties of Functions. 1970.~Stein E.M. and Weiss. G. Introduction to Fourier Analysis on Euclidean Spaces. 1975.~Sadosky C. Interpolation of Operators and Singular integrals. 1979.

MA 305 (JAN) 3:0

Analysis on Lie Groups

Thangavelu S

MA 341 (JAN) 3:0

Matrix Analysis and Positivity

Apoorva Khare

MA 332 (JAN) 3:0
Algebraic Topology

Subhojoy Gupta

MA 344 (JAN) 3:0
Homogenization of Partical Differential Equations

Nandakumaran A K

MA 218 (JAN) 3:0
Number Theory

Soumya Das

MA 201 (JAN) 7:0
Project

Manjunath Krishnapur

MA 399 (JAN) 2:0

Seminar in Topics in Mathematics

Kaushal Verma

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Astronomy and Astrophysics

AA 365 (JAN) 3:0

Galaxies and Interstellar Medium

Galactic structure: local and large scale distribution of stars and interstellar matter, the spiral structure, the galactic centre. Galactic dynamics, stellar relaxation, dynamical friction, star clusters, density wave theory of galactic spiral structure, chemical evolution in the galaxy, stellar populations. Galaxies, morphological classification of galaxies, active galaxies, clusters of galaxies, interactions of galaxies, dark matter, evolution of galaxies.

Nirupam Roy

Mihalas, D. and Binney, J.: Galactic Astronomy.,Binney, J. and Tremaine, S.: Galactic Dynamics,Spitzer, L.: Physical Process in the Interstellar Medium.

AA 377 (JAN) 0:2

Astronomical Techniques (Seminar Course)

Radio: coordinate system, detection principles, resolution and sensitivity, interferometry and aperturesynthesis. IR/Optical/UV: CCD fundamentals, imaging systems, point-spread-function, sensitivity, photometry and spectroscopy, speckle techniques, adaptive optics. X-ray/Gamma-ray astrophysics: detection principles, detectors and imaging systems, resolution and sensitivity, detector response, data analysis methods for spectroscopic and timing studies. Coordinated laboratory / data analysis exercises in each of the three areas.

Nirupam Roy

Christianson, W.N., & Hogbohm, J.A.: Radio Telescopes Roy, A.E., & Clarke, D.: Astronomy Principles and Practice.,Kitchin, C.R.: Astrophysical Techniques.,G.F.Knoll;, Radiation Detection and Measurement (2nd ed), Wiley, NY N.Tsoulfanidis, Measurement and Detection of Radiation (2nd ed), Taylor & Francis, Washington DC

AA 371 (JAN) 3:0

General Relativity & Cosmology

Foundations of general relativity. Elements of tensor analysis. Schwarzschild and Kerr spacetimes. Black hole physics. Gravitational radiation. Cosmological models. Observational tests. The early universe. The microwave background. Formation of structures.

Banibrata Mukhopadhyay

Landau, L.D., and Lifshitz, E.M.: The Classical Theory of Fields.,Weinberg, S.: Gravitation and Cosmology.,Peebles, P.J.E.: Physical Cosmology.

Dept of Physics

Integrated Ph D Programme
Physical Sciences

Departmental Core Courses

PH 201 3:0 Classical Mechanics
PH 202 3:0 Statistical Mechanics
PH 203 3:0 Quantum Mechanics I
PH 204 3:0 Quantum Mechanics II
PH 205 3:0 Mathematical Methods of Physics
PH 206 3:0 Electromagnetic Theory
PH 207 1:2 Analog Digital and Microprocessor Electronics
PH 208 3:0 Condensed Matter Physics-I
PH 209 2:1 Analog and Digital Electronics Lab
PH 211 0:3 General Physics Laboratory
PH 212 0:3 Experiments in Condensed Matter Physics
PH 213 0:4 Advanced Experiments in Condensed Matter Physics
HE 215 3:0 Nuclear and Particle Physics
PH 217 3:0 Fundamentals of Astrophysics
PH 231 0:1 Workshop practice
PH 300 1:0 Seminar Course

Project:
PH 250A 0:6 Project
PH 250B 0:6 Project

Elective Courses:
HE 316 3:0 Advanced Mathematical Methods
PH 320 3:0 Condensed Matter Physics II
PH 325 3:0 Advanced Statistical Physics
PH 330 0:3 Advanced Independent Project
PH 340 4:0 Quantum Statistical Field Theory
PH 347 2:0 Bioinformatics
PH 350 3:0 Physics of Soft Condensed Matter
PH 351 3:0 Crystal Growth, Thin Films and Characterization
PH 352 3:0 Semiconductor Physics and Technology
PH 359 3:0 Physics at the Nanoscale
PH 362 3:0 Matter at Low Temperatures
HE 392 3:0 Standard Model of Particle Physics
HE 395 3:0 Quantum Mechanics III
HE 396 3:0 Gauge Field Theories

PH 392 (AUG) 3:0

Standard model particle physics

Aninda Sinha

PH 391 (AUG) 3:0

Quantum Mechanics III

Apoorva Patel

PH 395 (AUG) 3:0

Quantum Field Theory I

Prasad Satish Hegde

PH 209 (AUG) 2:1

Electronics II

Introduction to microprocessors, Intel 80x86 architecture and instruction set. Assembly and C level programming, memory and IO interfacing. Mini projects using integrated circuits, data acquisition systems. PC add-on boards. Introduction to virtual instrumentation

Rajan K

Hall~D.V.~Digital circuits and systems~McGraw Hill International Electronic Engineering Series.~Hall

PH 211 (AUG) 0:3

General Physics Laboratory

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 triglycine selenate, random walk in porous medium

Victor Suvisesha Muthu D

practical course~practical course~practicals

PH 330 (AUG) 0:3

Advanced Independent Project

Open to research students only

Project Course,Project Course,Project Course

PH 325 (AUG) 3:0

Advanced Statistical Physics

Systems and phenomena. Equilibrium and non-equilibrium models. Techniques for equilibrium statistical mechanics with examples, exact solution, mean field theory, perturbation expansion, Ginzburg Landau theory, scaling, numerical methods. Critical phenomena, classical and quantum. Disordered systems including percolation and spin glasses. A brief survey of non-equilibrium phenomena including transport, hydrodynamics and non-equilibrium steady states.

Rahul Pandit

Chaikin,P.M.,and Lubensky,T.C.,Principles of Condensed Matter Physics

PH 213 (AUG) 0:4

Advanced Experiments in Condensed matter physics

Advanced experiments

Ganesan R, Anil Kumar P S

practical course,practical course,practical course

PH 215 (AUG) 3:0

Nuclear and Particle Physics

Yukawa potential. Isospin, neutron and proton. Deuteron. Shell model, magic numbers. Nuclear transitions, selection rules. Liquid drop model, collective excitations. Nuclear fission and fusion. Beta decay. Neutrinos. Fermi theory, parity violation, V-A theory. Mesons and baryons. Lifetimes and decay processes. Discrete symmetries, C, P, T and G. Weak interaction transition rules. Strangeness, K mesons and hyperons. Hadron multiplets, composition of mesons and baryons. Quark model and quantum chromodynamics

Jyothsna Rani Komaragiri

An Introduction to Physical Concepts (Second edition),Springer,1999. Krane K.S.,Introductory Nuclear Physics,John Wiley & Sons

PH 351 (AUG) 3:0

Crystal Growth, Thin films and Characterization

Basic concepts and experimental methods of crystal growth: nucleation phenomena, mechanisms of growth, dislocations and crystal growth, crystal dissolutions, phase equilibria, phase diagrams and material preparation, growth from liquid-solid equilibria, vapour- solid equilibria, monocomponent and multi-component techniques. Thin film growth and characterization: concepts of ultra high vacuum, nucleation and growth mechanisms, deposition techniques such as sputtering, evaporation, LPE,MOCVD, MBE, PLD, etc., thick ness measurements and characterization such as RHEED, LEED thin-film XRD, etc.

Suja Elizabeth, Anil Kumar P S

PH 201 (AUG) 3:0

Classical Mechanics

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.

Rajeev Kumar Jain

Goldstein,H.,Classical Mechanics,Second Edn,Narosa

PH 203 (AUG) 3:0

Quantum Mechanics-I

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. Threedimensional 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-levelsystems.

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

PH 205 (AUG) 3:0

Math Methods of Physics

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

Ananthanarayan B

Mathews,J.,and Walker,R.L.,Mathematical Methods of Physics

PH 209 (AUG) 2:1

Electronics II

Introduction to microprocessors, Intel 80x86 architecture and instruction set. Assembly and C level programming, memory and IO interfacing. Mini projects using integrated circuits, data acquisition systems. PC add-on boards. Introduction to virtual instrumentation

Rajan K

Hall,D.V.,Digital circuits and systems,McGraw Hill International Electronic Engineering Series.,Hall

PH 211 (AUG) 0:3

General Physics Laboratory

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 triglycine selenate, random walk in porous medium

Victor Suvisesha Muthu D, Vasant Natarajan, Srimanta Middey

practical course,practical course,practicals

PH 217 (AUG) 3:0

Fundamentals of Astrophysics

Overview of the major contents of the universe. Basics of radiative transfer and radiative processes. Stellar interiors. HR diagram. Nuclear energy generation. White dwarfs and neutron stars. Shape, size and contents of our galaxy. Basics of stellar dynamics. Normal and active galaxies. High energy and plasma processes. Newtonian cosmology. Microwave background. Early universe.

Tarun Deep Saini

Choudhuri,A.R.,Astrophysics for Physicists,Shu,F.

PH 300 (AUG) 0:1

Seminar Course

The course aims to help the fresh research student in seminar preparation, presentation and participation. The seminars will be given by the course registrants, after proper guidance by the instructors.

Arindam Ghosh, Anindya Das

Seminar course,Seminar Course,Seminar Course,Regular PhD students in physics

PH 320 (AUG) 3:0

Condensed Matter Physics II

Review of one-electron band theory. Effects of electron-electron interaction: Hartree – Fock approximation, exchange and correlation effects, density functional theory, Fermi liquid theory, elementary excitations, quasiparticles. Dielectric function of electron systems, screening, plasma oscillation. Optical properties of metals and insulators, excitons. The Hubbard model, spin-and charge-density wave states, metal-insulator transition. Review of harmonic theory of lattice vibrations. Anharmonic effects. Electron-phonon interaction – phonons in metals, mass renormalization, effective interaction between electrons, polarons. Transport phenomena, Boltzmann equation, electrical and thermal conductivities, thermo-electric effects. Superconductivity–phenomenology, Cooper instability, BCS theory, Ginzburg-Landau theory

Sumilan Banerjee

Ashcroft,N.W.,and Mermin,N.D.,Solid State Physics

PH 231 (AUG) 0:1

Workshop Practice

Use of lathe, milling machine, drilling machine, and elementary carpentry. Working with metals such as brass, aluminium and steel

Vasant Natarajan

practical course,practical course,practical course

PH 208 (JAN) 3:0

Condensed Matter Physics-I

Drude model, Sommerfeld model, crystal lattices, reciprocal lattice, X-ray diffraction, Brillouin zones and Fermi surfaces, Bloch's theorem, nearly free electrons, tight binding model, selected band structures, semi-classical dynamics of electrons, measuring Fermi surfaces, cohesive energy, classical harmonic crystal, quantum harmonic crystal, phonons in metals, semiconductors, diamagnetism and paramagnetism, magnetic interactions.

Anindya Das

Ashcroft, N.W., and Mermin, N.D., Solid State Physics, Holt-Saunders International, NY, 1976.,Kittel, C., Introduction to Solid State Physics, 5th/6th/7th editions, Wiley International, Singapore.,Ashcroft, N.W., and Mermin, N.D., Solid State Physics, Holt-Saunders International, NY, 1976.

PH 359 (JAN) 3:0

Physics at the Nanoscale

Introduction to different nanosystems and their realization, electronic properties of quantum confined systems: quantum wells, wires, nanotubes and dots. Optical properties of nanosystems: excitons and plasmons, photoluminescence, absorption spectra, vibrational and thermal properties of nanosystems, Zone folding. Raman characterization

Arindam Ghosh, Ambarish Ghosh

Delerue,C and Lannoo, M., Nanostructures: Theory and Modelling, Springer, 2006.,Saito, R., Dresselhaus, G., and Dresselhaus, M.S., Physical Properties of Carbon Nanotubes, Imperial College Press.,Delerue,C and Lannoo, M., Nanostructures: Theory and Modelling, Springer, 2006.

PH 354 (JAN) 3:0

Computational physics

Introduction to computational physics; Machine representation, precision and errors; Roots of equations; Quadrature; Random numbers and Monte-Carlo Fourier methods Ordinary differential equations Numerical Linear algebra

Manish Jain

Mark Newman, Computational Physics, Createspace Independent Publishing (2015).,Rubin H. Landau, Manuel J. Paez and Cristian Bordeianu, Computational Physics, 3rd Ed Problem Solving with Python, Wiley (2015).,A. Klein and A. Godunov, Introductory Computational Physics, Cambridge University Press (2006),Forman Acton, Real computing made real: Preventing Errors in Scientific and Engineering Calculations, Dover Publications. Lloyd N. Trefethen and David Bau, Numerical Linear Algebra, SIAM.

PH 365 (JAN) 3:0

Galaxies and Interstellar Medium

Galactic structure: local and large scale distribution of stars and interstellar matter, the spiral structure, the galactic centre. Galactic dynamics, stellar relaxation, dynamical friction, star clusters, density wave theory of galactic spiral structure, chemical evolution in the galaxy, stellar populations. Galaxies, morphological classification of galaxies, active galaxies, clusters of galaxies, interactions of galaxies, dark matter, evolution of galaxies.

Nirupam Roy

Mihalas, D. and Binney, J.: Galactic Astronomy.,Binney, J. and Tremaine, S.: Galactic Dynamics,Spitzer, L.: Physical Process in the Interstellar Medium

PH 206 (JAN) 3:0

Electromagnetic Theory

Laws of electrostatics and methods of solving boundary value problems. Multi-pole expansion of electrostatic potentials, spherical harmonics. Electrostatics in material media, dielectrics. BiotSavart Law, magnetic field and the vector potential. Faraday's Law and time varying fields. Maxwell's equations, energy and momentum of the electromagnetic field, Poynting vector, conservation laws. Propagation of plane electromagnetic waves. Radiation from an accelerated charge, retarded and advanced potentials, Lienard-Wiechert potentials, radiation multi-poles. Special theory of relativity and its application in electromagnetic theory. Maxwell's equations in covariant form: four – potentials, electromagnetic field tensor, field Lagrangian. Elements of classical field theory, gauge invariance in electromagnetic theory.

Animesh Kuley

Jackson, J.D., Classical Electrodynamics, Third Edn, John Wiley.,Panofsky, W.K.H., and Phillips, M., Classical Electricity and Magnetism, Second Edn, Dover,Jackson, J.D., Classical Electrodynamics, Third Edn, John Wiley

PH 352 (JAN) 3:0

Semiconductor Physics

Semiconductor fundamentals: band structure, electron and hole statistics, intrinsic and extrinsic semiconductors, energy band diagrams, drift-diffusion transport, generation - recombination, optical absorption and emission. Basic semiconductor devices: on junctions, bipolar transistors, MOS capacitors, field-effect devices, optical detectors and emitters. Semiconductor technology: fundamentals of semiconductor processing techniques; introduction to planar technology for integrated circuits

Venkataraman V

Seeger, K., Semiconductor Physics, Springer-Verlag, 1990.,Sze, S.M., Physics of Semiconductor Devices, Wiley, 1980.,Muller, K., and Kamins, T., Device Electronics for Integrated Circuits, John Wiley, 1977.

PH 212 (JAN) 0:3

Experiments in Condensed.

Hall coefficient carrier mobility and life-time in semiconductors, resistivity measurement in anisotropic materials, crystal growth, crystal optics, light scattering, electron tunneling, resonance spectroscopy, coexistence curve for binary liquid mixtures, magnetic susceptibility, dielectric loss and dispersion. Meissner fraction of a high temperature superconductor, specific heat of a glass, microwave and rf absorption in high Tc materials, surface studies by STM in air, electron tunneling/STM magnetic susceptibility, calibration of a cryogenic temperature sensor (oxide/Ge sensor), resistivity vs temperature of a superconductor.

Koteswara Rao K S R, Victor Suvisesha Muthu D

Weider, Lab. notes of electrical measurements.,Smith and Richardson, Experimental methods in low temperature physics.,Weider, Lab. notes of electrical measurements.

PH 364 (JAN) 3:0

Topological Phases of Matter (Theory and experiment)

The course is designed to teach the concepts and methods of various forms of topological phases of matter to mainly physics students. Some related concepts and their extensions such as Aharonov-Bohm effect, Berry phase, graphene, Majorana, Weyl fermions will also be taught. This is a combined theory and experimental course (no experiment will however be performed). Students are expected to have taken condensed matter I, but no prior knowledge of group theory is required.

Aveek Bid, Tanmoy Das

“Topological insulators”, Shun-Qing Shen, Springer “Topological insulators and topological superconductors” B. Andrei Bernevig, and T. L. Hughes, Princeton University Press,“Topological insulators- The physics of spin helicity in quantum transport” G. Tkachov, Pan Stanford publishing,“Topological insulators” Marcel Franz, and L. Molenkamp, Elsevier “Colloquium: Topological band theory”, A. Bansil. H. Lin and T. Das, Rev. Mod. Phys. 88, 021004 (2016).,“Colloquium: Topological insulators”, M. Z. Hasan, C. L Kane, Rev. Mod. Phys. 82, 3045 (2010).,“Topological insulators and superconductor”, X.-L. Si, S.-C. Zhang, Rev. Mod. Phys. 83, 1057 (2011).

PH 207 (JAN) 1:2

Electronics I

Basic diode and transistor circuits, operational amplifier and applications, active filters, voltage regulators, oscillators, digital electronics, logic gates, Boolean algebra, flip-flops, multiplexers, counters, displays, decoders, D/A, A/D. Introduction to microprocessors.

Rajan K

Horowitz and Hill, The Art of Electronics, Second Edn.,Millman and Halkias, Integrated Electronics, McGraw Hill.,Horowitz and Hill, The Art of Electronics, Second Edn.

PH 322 (JAN) 3:0

Molecular Simulation

Introduction to molecular dynamics, various schemes for integration, inter- and intra-molecular forces, introduction to various force fields, methods for partial atomic charges, various ensembles (NVE, NVT, NPT, NPH), hard sphere simulations, water imulations, computing long-range interactions. Various schemes for minimization: conjugate radient, steepest descents. Monte Carlo simulations, the Ising model, various sampling methods, particle-based MC simulations, biased Monte Carlo. Density functional theory, free energy calculations, umbrella sampling, smart Monte Carlo, liquid crystal simulations, introduction to biomolecule simulations

Prabal Kumar Maiti

Prerequisites: Basic courses in statistical physics, quantum mechanics,Prerequisites: Basic courses in statistical physics, quantum mechanics,Prerequisites: Basic courses in statistical physics, quantum mechanics

PH 371 (JAN) 3:0

General Relativity & Cosmology

Foundations of general relativity. Elements of tensor analysis. Schwarzschild and Kerr spacetimes. Black hole physics. Gravitational radiation. Cosmological models. Observational tests. The early universe. The microwave background. Formation of structures.

Banibrata Mukhopadhyay

Landau, L.D., and Lifshitz, E.M.: The Classical Theory of Fields.,Weinberg, S.: Gravitation and Cosmology.,Peebles, P.J.E.: Physical Cosmology.

PH 250 (JAN) 0:6

Project I

This two part project starts in the fourth semester of the Integrated Ph.D Programme (PH 250 A) and ends in the summer before the beginning of the 5th semester (PH 250B).

Project Course,Project Course,Project Course

PH 202 (JAN) 3:0

Statistical Mechanics

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.

Justin Raj David

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 (JAN) 3:0

Quantum Mechanics II

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 nonrelativistic reduction, g factor of the electron.

Biplob Bhattacherjee

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

PH 377 (JAN) 0:2

Astronomical Techniques (Seminar Course)

Radio: coordinate system, detection principles, resolution and sensitivity, interferometry and aperturesynthesis. IR/Optical/UV: CCD fundamentals, imaging systems, point-spread-function, sensitivity, photometry and spectroscopy, speckle techniques, adaptive optics. X-ray/Gamma-ray astrophysics: detection principles, detectors and imaging systems, resolution and sensitivity, detector response, data analysis methods for spectroscopic and timing studies. Coordinated laboratory / data analysis exercises in each of the three areas.

Nirupam Roy

Christianson, W.N., & Hogbohm, J.A.: Radio Telescopes Roy, A.E., & Clarke, D.: Astronomy Principles and Practice.,Kitchin, C.R.: Astrophysical Techniques.,G.F.Knoll;, Radiation Detection and Measurement (2nd ed), Wiley, NY N.Tsoulfanidis, Measurement and Detection of Radiation (2nd ed), Taylor & Francis, Washington DC

PH 316 (JAN) 3:0

Advanced Mathematical Methods

Symmetries and group theory. Finite and continuous groups with examples. Group operations and representations. Homomorphism, isomorphism and automorphism. Reducibility, equivalence, Schur's lemma. Permutation groups, Young diagrams. Lie groups and Lie algebras. SU(2), SU(3) and applications. Roots and weights. Dynkin diagrams. Classification of compact simple Lie algebras. Exceptional groups. Elements of topology and homotopy.

Sachindeo Vaidya

Georgi H., Lie Algebras in Particle Physics (Second edition), Perseus Books, 1999.,Mukhi S. and Mukunda N., Introduction to Topology, Differential Geometry and Group Theory for Physicists, Wiley Eastern, 1990,Hamermesh M., Group Theory and its Applications to Physical Problems, Addison-Wesley, 1962.

PH 396 (JAN) 3:0

Quantum Field Theory 2

Abelian gauge theories. QED processes and symmetries. Loop diagrams and 1-loop renormalization. Lamb shift and anomalous magnetic moments. Nonabelian gauge theories. Faddeev-Popov ghosts. BRST quantization. QCD beta function, asymptotic freedom. Spinor helicity formalism for gauge theories. Composite operators, operator product expansion. Anomalies. Lattice gauge theory, strong coupling expansion. Confinement and chiral symmetry breaking.

Chethan Krishnan

Schwartz M.D., Quantum field theory and the standard model, Cambridge University Press, 2014.,Srednicki M., Quantum Field Theory, Cambridge University Press, 2007.,Peskin M.E. and Schroeder D.V., An Introduction to Quantum Field Theory, Addison Wesley, 1995.,Weinberg S., The Quantum Theory of Fields, Vol. I: Foundations, Vol. II: Modern Applications, Cambridge University Press, 1996.

PH 350 (JAN) 3:0

Physics of Soft Condensed Matter

Phases of soft condensed matter, colloidal fluids and crystals, polymer solutions, gels and meltsMicelles, vesicles, surfactant mesophaes, polymer colloids, microgels and star polymers-particles with tunable soft repulsive interaction, surfactant and phospolipid membranes. Lyotropic liquid crystals. Structure and dynamics of soft matter, electrostatics in soft matter, dynamics at equilibrium. Glass formation and jamming, dynamical heterogeneity. Soft glassy rheology. Shear flow, linear and nonlinear rheology, visco-elastic models, Introductory biological physics. Active matter. Experimental methods, Small angle scattering and diffraction, Dynamic light scattering and diffusive wave spectroscopy, dynamics of soft matter using synchrotron X-ray and neutron scattering, rheometry. Conforcal microscopy.

Jaydeep Kumar Basu

Prerequisite: Knowledge of basic statistical mechanics Jones, R.A.L. Soft Condensed Matter, Oxford University Press, 2002,Rubinstein, M., and Colby, R.H. Polymer Physics, Oxford, 2003,Doi and Edwards, Theory of Polymer Dynamics, Clarendon, Oxford, 1988

PH 398 (JAN) 3:0

General Relativity

Review of tensor calculus and properties of the Riemann tensor. Killing vectors, symmetric spaces. Geodesics. Equivalence principle and its applications. Scalars, fermions and gauge fields in curved space-time. Einstein's equations and black hole solutions. Schwarzschild solution, Motion of a particle in the Schwarzschild metric. Kruskal extension and Penrose diagrams. ReissnerNordstrom solution, Kerr solution. Laws of black hole physics. Gravitational collapse. Oppenheimer-Volkoff and Oppenheimer-Synder solutions, Chandrasekhar limit. Csomological models, Friedmann-Robertson-Walker metric. Open, closed and flat universes. Introduction to quantizing fields in curved spaces and Hawking radiation.

Aninda Sinha

Landau L.D. and Lifshitz E.M., The Classical Theory of Fields, Pergamon Press, 1975.,Weinberg S., Gravitation and Cosmology: Principles and Applications of the General Theory of Relativity, John Wiley & Sons, 1972,,Wald R.M., General Relativity, Overseas Press, 2006.,Wald R.M., General Relativity, Overseas Press, 2006.,G. 't Hooft, Inroduction to General Relativity, Introduction to the theory of Black Holes, http://www.phys.uu.nl/~thooft/

PH 250A (JAN) 0:6

Project I

This two part project starts in the fourth semester of the Integrated Ph.D Programme (PH 250 A) and ends in the summer before the beginning of the 5th semester

Arindam Ghosh

PH 335 (JAN) 3:0

Modern Topics in Condensed Matter

Sriram Ramaswamy, Rahul Pandit

PH 208 (JAN) 3:0

Condensed Matter Physics-I

Srimanta Middey

PH 364 (MAY) 3:0

Topological Phases of Matter

Aveek Bid, Tanmoy Das

PH 250B (MAY) 0:6

Project

Centre for High Energy Physics

HE 397 (AUG) 3:0

The Standard Model of Particle Physics

Weak interactions before gauge theory. V-A theory, massive vector bosons. Spontaneous symmetry breaking, Goldstone bosons, Higgs mechanism. Charged and neutral currents, gauge symmetries and SU(2)xU(1) Lagrangian. Flavour mixing, GIM mechanism. CP violation, K/B systems. Neutrinos. Electroweak precision measurements. Deep inelastic scattering, parton model. Chiral Lagrangians and heavy quark effective field theories. Introduction to supersymmetry and extra dimensions.

Aninda Sinha

Georgi H.,Weak Interactions and Modern Particle Theory,Benjamin/Cummings,1984~Halzen F. and Martin A.D., Quarks and Leptons: An Introductory Course in Modern Particle Physics, John Wiley & Sons, 1984~Pokorski S., Gauge Field Theories (Second edition), Cambridge University Press, 2000~Peskin M.E. and Schroeder D.V., An Introduction to Quantum Field Theory, Addison Wesley, 1995~

HE 395 (AUG) 3:0

Quantum Field Theory I

Scalar, spinor and vector fields. Canonical quantisation, propagators. Symmetries and Noether theorem. Path integrals for bosonic and fermionic fields, generating functionals. Feynman diagrams. S-matrix, LSZ reduction formula. Interacting scalar and Yukawa theories. Covariant derivatives and gauge theories. Quantum electrodynamics. Gauge invariance, massless photons, Ward identity. Elementary processes. Scattering cross-sections, optical theorem, decay rates. Loop diagrams, power counting, divergences. Renormalization, fixed point classification. One loop calculations in QED. Callan-Symanzik equations, beta functions. Effective field theory.

Prasad Satish Hegde

Zee A.,Quantum Field Theory in a Nutshell (Second edition),Princeton University Press,2010~Srednicki M., Quantum Field Theory, Cambridge University Press, 2007~Ryder L.H., Quantum Field Theory (Second edition), Cambridge University Press, 1996~Ramond P., Field Theory: A Modern Primer (Second edition), Levant Books, 2007~

HE 215 (AUG) 3:0

Nuclear and Particle Physics

Radioactive decay, subnuclear particles. Binding energies. Nuclear forces, pion exchange, Yukawa potential. Isospin, neutron and proton. Deuteron. Shell model, magic numbers. Nuclear transitions, selection rules. Liquid drop model, collective excitations. Nuclear fission and fusion. Beta decay. Neutrinos. Fermi theory, parity violation, V-A theory. Mesons and baryons. Lifetimes and decay processes. Discrete symmetries, C, P, T and G. Weak interaction transition rules. Strangeness, K mesons and hyperons. Hadron multiplets, composition of mesons and baryons. Quark model and quantum chromodynamics.

Jyothsna Rani Komaragiri

Povh B.,Rith K.,Scholz C. and Zetsche F., Particles and Nuclei: An Introduction to Physical Concepts (Second edition), Springer, 1999~Krane K.S., Introductory Nuclear Physics, John Wiley & Sons, 1988~Griffiths D., Introduction to Elementary Particles, John Wiley & Sons, 1987~Perkins D.H., Introduction to High Energy Physics (Third edition), Addison-Wesley, 1987~

HE 391 (AUG) 3:0

Quantum Mechanics III

Path integrals in quantum mechanics. Action and evolution kernels. Free particle and harmonic oscillator solutions. Perturbation theory, transition elements. Fermions and Grassmann integrals. Euclidean time formulation, statistical mechanics at finite temperature. Relativistic quantum mechanics, Klein-Gordon and Dirac equations. Antiparticles and hole theory. Klein paradox. Nonrelativistic reduction. Coulomb problem solution. Symmetries P, C and T, spin-statistics theorem. Lorentz and Poincare groups. Wigner classification of single particle states. Weyl and Majorana fermions. Modern topics such as graphene, Kubo formulae.

Apoorva Patel

Feynman R.P. and Hibbs A.R., Quantum Mechanics and Path Integrals, McGraw-Hill, 1965~Bjorken J.D. and Drell S., Relativistic Quantum Mechanics, McGraw-Hill, 1965~Greiner W., Relativistic Quantum Mechanics: Wave Equations (Third edition), Springer, 1990~Peskin M.E. and Schroeder D.V., An Introduction to Quantum Field Theory, Addison Wesley, 1995

HE 396 (JAN) 3:0

Quantum Field Theory II

Abelian gauge theories. QED processes and symmetries. Loop diagrams and 1-loop renormalization. Lamb shift and anomalous magnetic moments. Nonabelian gauge theories. Faddeev-Popov ghosts. BRST quantization. QCD beta function, asymptotic freedom. Spinor helicity formalism for gauge theories. Composite operators, operator product expansion. Anomalies. Lattice gauge theory, strong coupling expansion. Confinement and chiral symmetry breaking.

Sudhir Kumar Vempati

Schwartz M.D., Quantum field theory and the standard model, Cambridge University Press, 2014.,Srednicki M., Quantum Field Theory, Cambridge University Press, 2007.,Peskin M.E. and Schroeder D.V., An Introduction to Quantum Field Theory, Addison Wesley, 1995.,Weinberg S., The Quantum Theory of Fields, Vol. I: Foundations, Vol. II: Modern Applications, Cambridge University Press, 1996.~Bjorken J.D. and Drell S., Relativistic Quantum Mechanics, McGraw-Hill, 1965~Greiner W., Relativistic Quantum Mechanics: Wave Equations (Third edition), Springer, 1990~Peskin M.E. and Schroeder D.V., An Introduction to Quantum Field Theory, Addison Wesley, 1995~

HE 316 (JAN) 3:0

Advanced Mathematical Methods in Physics

Symmetries and group theory. Finite and continuous groups with examples. Group operations and representations. Homomorphism, isomorphism and automorphism. Reducibility, equivalence, Schur's lemma. Permutation groups, Young diagrams. Lie groups and Lie algebras. SU(2), SU(3) and applications. Roots and weights. Dynkin diagrams. Classification of compact simple Lie algebras. Exceptional groups. Elements of topology and homotopy.

Sachindeo Vaidya

Georgi H., Lie Algebras in Particle Physics (Second edition), Perseus Books, 1999~Mukhi S. and Mukunda N., Introduction to Topology, Differential Geometry and Group Theory for Physicists, Wiley Eastern, 1990~Hamermesh M., Group Theory and its Applications to Physical Problems, Addison-Wesley, 1962~~

HE 398 (JAN) 3:0

General Relativity

Review of tensor calculus and properties of the Riemann tensor. Killing vectors, symmetric spaces. Geodesics. Equivalence principle and its applications. Scalars, fermions and gauge fields in curved space-time. Einstein's equations and black hole solutions. Schwarzschild solution, Motion of a particle in the Schwarzschild metric. Kruskal extension and Penrose diagrams. Reissner-Nordstrom solution, Kerr solution. Laws of black hole physics. Gravitational collapse. Oppenheimer-Volkoff and Oppenheimer-Synder solutions, Chandrasekhar limit. Csomological models, Friedmann-Robertson-Walker metric. Open, closed and flat universes. Introduction to quantizing fields in curved spaces and Hawking radiation.

Justin Raj David

Landau L.D. and Lifshitz E.M.,The Classical Theory of Fields,Pergamon Press,1975~Weinberg S., Gravitation and Cosmology: Principles and Applications of the General Theory of Relativity, John Wiley & Sons, 1972~Wald R.M., General Relativity, Overseas Press, 2006~'t Hooft G., Inroduction to General Relativity, Introduction to the theory of Black Holes, http://www.phys.uu.nl/~thooft/~

HE 384 (JAN) 3:0

Quantum Computation

Foundations of quantum theory. States, observables, measurement and unitary evolution. Qubits versus classical bits, spin-half systems and photon polarisations. Pure and mixed states, density matrices. Extension to positive operator valued measures and superoperators. Decoherence and master equations. Quantum entanglement and Bell's theorems. Introduction to classical information theory and generalisation to quantum information. Dense coding, teleportation and quantum cryptography. Turing machines and computational complexity. Reversible computation. Universal quantum logic gates and circuits. Quantum algorithms: database search, FFT and prime factorisation. Quantum error correction and fault tolerant computation. Physical implementations of quantum computers.

Nielsen M.A. and Chuang I.L.,Quantum Computation and Quantum Information,Cambridge University Press,2000~Preskill J., Lecture Notes for the Course on Quantum Computation, http://www.theory.caltech.edu/people/preskill/ph229~Peres A., Quantum Theory: Concepts and Methods, Kluwer Academic, 1993~~

HE 386 (JAN) 3:0

Experimental High Energy Physics

Particles and interactions in the standard model. Strong, weak and electromagnetic interactions. Kinematics of particle interactions. Concepts of accelerators, linear and circular Accelerators. Introduction to particle detectors, interaction of particles with matter. Gaseous detectors, scintillator detectors, solid state detector. Readout electronics, vertex detection and tracking. Calorimetry for electrons, photons, charged hadrons and neutrons. Particle identification and detector systems. Experimental tests of the building blocks of matter and their fundamental interactions. Examples of QCD tests, top quark, Z and W bosons, Higgs boson, new particle searches. Review of some particle physics experiments, concepts of collider physics, basic phenomenology of a hard scattering process. Data analysis techniques in collider physics, statistical analysis in particle physics.

Somnath Choudhury

Perkins D.H., Introduction to High Energy Physics (Third edition), Addison-Wesley, 1987~Leo W.R., Techniques for Nuclear and Particle Physics Experiments: A How to Approach (Second revised edition) Narosa/Springer International, 2012~Knoll G.F., Radiation Detection and Measurement (Fourth edition), Wiley, 2010~Grupen C. and Schwartz B., Particle Detectors (Second edition), Cambridge University Press, 2011~Fernow R.C., Introduction to Experimental Particle Physics Cambridge University Press, 1986

HE 322 (JAN) 3:0

QCD and Collider Physics

Review of perturbative QCD. Monte Carlo simulations and event generators. Jet physics, event shape variables. Tests of the structure of QCD, jet substructure analysis. Introduction to lepton and hadron collider basics, Higgs and heavy quark production at the LHC, search for new physics at the LHC. Supersymmetry, extra dimension and dark matter. Statistical analysis and limit setting.

Biplob Bhattacherjee

Ellis R., Stirling W. and Webber B., QCD and Collider Physics, (Cambridge Monographs on Particle Physics, Nuclear Physics and Cosmology) Cambridge University Press, 1996~Plehn T., Lectures on LHC Physics, Springer, 2012 [arXiv:0910.4182v6]~Barger V.D. and Phillips R.J.N., Collider Physics (updated edition), CRC Press, 1996~Cowan G., Statistical Data Analysis Oxford Science Publications, 1998~

Division of Electrical, Electronics and Computer Sciences (EECS)

Preface

The Division of EECS comprises the Departments of Computer Science and Automation (CSA), Electrical Communication Engineering (ECE), Department of Electronic Systems Engineering (DESE), and Electrical Engineering (EE). The courses offered in these departments have been grouped into ten technical areas identified by the following codes which appear as prefixes to the course numbers.

E0	Computer Science and Engineering
E1	Intelligent Systems and Automation
E2	Communication Systems
E3	Electronic Devices, Circuits and Technology
E4	Power and Energy Systems
E5	High Voltage and Insulation Engineering
E6	Power Electronics and Drives
E7	Photonic Devices, Circuits and Systems
E8	Electromagnetic, Microwaves and Antennas
E9	Signal Processing, Acoustics and Bioengineering
EP	Dissertation Project

All departments of the Division provide facilities for research work leading to the Ph D and M Tech (Research) degrees. The following course based Master’s programs are offered individually or jointly by the departments of the Division.

M Tech in Electrical Engineering (EE Department)
M Tech in Communication and Networks (ECE Department)
M Tech in Computer Science and Engineering (CSA Department)
M Tech in Electronics Systems Engineering (ESE Department)
M Tech in Systems Engineering (EE and CSA Departments.)
M Tech in Signal Processing (EE and ECE Departments)
M Tech in Microelectronic Systems (ECE and ESE Departments)

Prof. Y Narahari
Chairman,
Division of EECS

Department of Computer Science and Automation

POOL A

Course No	Credits	Course Title
E0 203	3:1	Spectral Algorithms
E0 220	3:1	Graph Theory
E0 221	3:1	Discrete Structures
E0 222	3:1	Automata Theory and Computability
E0 224	3:1	Computational Complexity Theory
E0 225	3:1	Design and Analysis of Algorithms
E0 228	3:1	Combinatorics
E0 229	3:1	Foundations of Data Science
E0 234	3:1	Introduction to Randomized Algorithms
E0 235	3:1	Cryptography
E0 244	3:1	Computational Geometry and Topology
E0 248	3:1	Theoretical Foundations of Cryptography
E0 249	3:1	Approximation Algorithms

POOL B

Course No	Credits	Course Title
E0 202	3:1	Automated Software Engineering with Machine Learning
E0 210	3:1	Principles of Programming
E0 227	3:1	Program Analysis and Verification
E0 239	3:1	Software Reliability Techniques
E0 243	3:1	Computer Architecture
E0 252	3:1	Programming Languages: Design and Implementation
E0 253	3:1	Operating Systems
E0 254	3:1	Network and Distributed Systems Security
E0 255	3:1	Compiler Design
E0 256	3:1	Theory and Practice of Computer Systems Security
E0 261	3:1	Database Management Systems
E0 264	3:1	Distributed Computing Systems
E0 271	3:1	Computer Graphics
E0 272	3:1	Formal Methods in Software Engineering

POOL C

Course No	Credits	Course Title
E0 219	3:1	Linear Algebra and Applications
E0 230	3:1	Computational Methods of Optimization
E0 232	3:1	Probability and Statistics
E0 236	3:1	Information Retrieval
E0 238	3:1	Artificial Intelligence
E0 267	3:1	Soft Computing
E0 268	3:1	Practical Data Science
E0 270	3:1	Machine Learning
E1 246	3:1	Natural Language Understanding
E1 254	3:1	Game Theory
E1 277	3:1	Reinforcement Learning

M.TechCommunication & Networks/(M.Tech(CN))

OVERALL STRUCTURE

The programme requires 36 units of coursework and 28 units of project work with a Major and Minor Structure.

MAJOR AND MINOR STRUCTURE

MINORS

(a) A new feature of the programme is that it give the students the option to graduate with one of 4 "Minors":
   (i) Minor in Integrated Circuits & Systems,
   (ii) Minor in Photonics,
   (iii) Minor in Radio-Frequency Systems
   (iv) Minor in Signal Processing
(b) The selection of a Minor is not however, mandatory.
(c) A student qualifies for a Minor if he/she takes at least 3 courses belonging to a basket of courses specific to each area.
(d) This basket of courses is further divided into two pools, Pool X and Pool Y and a student is required to take a total of 3 courses from Pool X and Pool Y combined and
   (i) at least two courses from Pool X in the case of a Minor in Integrated Circuits & Systems,
   (ii) at least one course from Pool X in the case of a Minor in either Photonics, Radio-Frequency Systems or Signal Processing.
(e) The selection of a minor takes place during the course of the programme by the student in consultation with his Faculty Advisor.
(f) It is understood that the default Major of all students enrolled in the programme is Communication & Networks.
(g) A student who does not opt for a Minor, can either choose to specialize further in the Major by taking 3 additional courses in the area of Communication & Networks or else choosing amongst the many electives available (in consultation with his/her Faculty Advisor).

SAMPLE COURSE-UNIT BREAKUP

Here is a sample breakup of course units for a student opting for one of the Minors and taking two courses with placement in mind.

Core	4 courses	12 units
Soft Core	3 courses	9 units
Electives	2 courses	6 units
Minor or Electrives	3 courses	9 units
Total		36 units

THE CORE

The following courses are required of every student in the programme and hence constitute the Core

(a) E2 202 (AUG) 3:0 Random Processes
(b) E2 211 (AUG) 3:0 Digital Communication
(c) E2 221 (AUG) 3:0 Communication Networks
(d) E1 244 (JAN) 3:0 Detection and Estimation Theory

SOFTCORE

(a) Students are required to take a total of 3 courses from the two pools, Pool A and B below.
(b) At least 2 of these courses must be from Pool A.

Pool A (in no particular order)
E2 201 (AUG) 3:0 Information Theory
E2 205 (AUG) 3:0 Error-Correcting Codes
E2 223 (AUG) 3:0 Communication Protocols

E2 242 (JAN) 3:0 CDMA & Multiuser Detection
E2 204 (JAN) 3:0 Stochastic Processes and Queueing Theory
E8 203 (AUG) 3:0 RF & Optical Engineering
E2 203 (JAN) 3:0 Wireless Communication
E2 241 (JAN) 3:0 Wireless Networks

Pool B (in no particular order)
E0 259 (AUG) 3:1 Data Analytics
E1 251 (AUG) 3:0 Linear and Nonlinear Optimization
E2 212 (AUG) 3:0 Matrix Theory
E9 201 (AUG) 3:0 Digital Signal Processing
E1 254 (AUG/JAN) 3:1 Game Theory
E9 211 (JAN) 3:0 Adaptive Signal Processing
E9 221 (AUG) 3:0 Signal Quantization and Compression
E9 202 (JAN) 3:0 Advanced Digital Signal Processing : Non-linear Filters

REQUIREMENTS FOR EACH MINOR

A. **Minor in Integrated Circuits and Systems (ICS)**

Requirements:

- Any 3 of the courses listed below under Pools X & Y
- with at least two courses from Pool X will qualify a student for a “Minor in Integrated Circuits and Systems”.

Pool X
NE 205 (Aug) 3:0 Semiconductor Devices and Integrated Circuit Technology
E3 238 (AUG) 2:1 Analog VLSI Circuits
E0 284 (AUG) 2:1 Digital VLSI Circuits
E7 211 (JAN) 3:0 Photonics Integrated Circuits

Pool Y
E3 237 (JAN) 3:0 Integrated circuits for Wireless Communication
E3 239 (JAN) 2:1 Advanced VLSI Circuits
E8 262 (JAN) 3:0 CAD for High Speed Chip-Package-Systems

B. **Minor in Photonics**

Requirements:

- Any 3 of the courses listed below under Pools X & Y
- with at least one course from Pool X will qualify a student for a “Minor in Photonics”.

Pool X
NE 213/E7 213 (Aug) 3:0 Introduction to Photonics
E8 203 (AUG) 3:0 RF & Optical Engineering
E7 231 (JAN) 3:0 Fiber-Optic Networks

Pool Y
E7 211 (JAN) 3:0 Photonics Integrated Circuits
E3 214 (AUG) 3:0 Microsensor Technologies)
IN 247 (JAN) 3:0 Principles of Tomographic

C. **Minor in Radio-Frequency Systems**

Requirements:

- Any 3 of the courses listed below under Pools X & Y
- with at least one course from Pool X will qualify a student for a "Minor in Radio-Frequency Systems".

Pool X
E8-242 (JAN) 2:1 Radio Frequency Integrated Circuits and Systems
E3 237 (JAN) 3:0 Integrated circuits for Wireless Communication

Pool Y
E8 202 (AUG) 2:1 Computational Electromagnetics
E8 203: (AUG) 3:0 RF & Optical Engineering (proposed new course)
E8 262 (JAN) 3:0 CAD for High Speed Chip-Package-Systems

D. **Minor in Signal Processing**

Requirements:

- Any 3 of the courses listed below under Pools X & Y
- with at least one course from Pool X will qualify a student for a "Minor in Signal Processing".

Pool X
E9 202 (JAN) 3:0 Advanced Digital Signal Processing : Non-linear Filters
E9 211 (JAN) 3:0 Adaptive Signal Processing
E9 212 (JAN) 3:0 Spectrum Analysis
E9 213 (JAN) 3:0 Time-Frequency Analysis
E9 221 (AUG) 3:0 Signal Quantization and Compression

Pool Y
E1 213 (JAN) 3:1 Pattern Recognition and Neural Networks
E1 216 (JAN) 3:1 Computer Vision
E9 203 (JAN) 3:0 Compressed Sensing and Sparse Signal Processing
E9 262 (JAN) 3:0 Stochastic Models for Speech/Audio
E9 231 (AUG) 3:0 Digital Array Signal Processing
E9 241 (AUG) 2:1 Digital Image Processing
E9 252 (AUG) 3:0 Mathematical methods and techniques in signal processing
E9 261 (AUG) 3:1 Speech Information Processing

DEPARTMENT OF ELECTRONIC SYSTEMS ENGINEERING

M Tech Programme

ELECTRONIC SYSTEMS ENGINEERING

Duration: 2 Years			**Total Credits: 64**
Core Courses: 18 credits (All courses are compulsory)			
E0 284	2:1	Aug	Digital VLSI Circuits
E2 243	2:1	Aug	Mathematics for Electrical Engineers
E3 235	2:1	Aug	Design for Analog Circuits
E3 262	2:1	Aug	Electronic Systems Packaging
E3 282	3:0	Aug	Basics of Semiconductor Devices and Technology
E6 202	2:1	Jan	Design of Power Converters
Electives: 21 Credits (all at 200 level or higher) from the following courses or any other courses listed in the Scheme of Instructions.			
E1 243	2:1	Jan	Digital Controller Design
E1 247	2:1	Aug	Incremental Motion Control
E1 261	3:0	Aug	Selected Topics in Markov Chains and Optimization
E2 222	3:0	Jan	Data Center Networking
E2 230	3:0	Aug	Network Science and Modeling
E2 231	3:0	Jan	Topics in Statistical Methods
E2 232	2:1	Aug	TCP-IP Networking
E3 225	3:0	Jan	Compact Modeling of Devices
E3 231	2:1	Jan	Digital System Design with FPGAs
E3 233	2:1	Aug	VLSI for Signal Processing
E3 245	2:1	Aug	Processor System Design
E3 257	2:1	Jan	Embedded System Design
E3 258	2:1	Jan	Design for Internet of Things
E3 271	3:0	Jan	Reliability of Nanoscale Circuits and Systems
E3 272	3:0	Jan	Advanced ESD Devices, Circuits and Design Methods
E3 274	3:0	Aug	Design of Power Semiconductor Devices
E3 275	3:0	Jan	Physics and Design of Transistors
E3 290	2:1	Jan	Microfabrication Tech and Process for Biology and Medicine
E6 212	3:0	Jan	Design and Control of Power Converters and Drives
E6 222	2:1	Jan	Design of Photovoltaic Systems
E9 207	3:0	Jan	Basics of Signal Processing
E9 251	3:0	Jan	Signal Processing for Data Recoding Channels
E9 252	3:0	Aug	Mathematical Methods and Techniques in Signal Processing
Project: 22 Credits			
EP 299	0:25		Dissertation Project

M Tech Programme in Electronic Systems Engineering has the following course structure

1. **Core courses** **18 credits**
2. **Elective courses** **21 credits**
3. **Project** **25 credits**

MTechProgramme in Electrical Engineering
(Duration 2 years)
64 Credits

Hard Core (ALL courses compulsory)		
E1 241	3:0	Dynamics of Linear Systems
E4 234	3:0	Advanced Power System Analysis
E5 201	3:0	Production, Measurement and Application of High Voltage
E6 201	2:1	Power Electronics

Soft Core (Any FOUR of the following six courses)		
E3 252	3:0	Digital controllers for Power Applications
E4 231	3:0	Power System Dynamics & Control
E4 233	3:0	Computer Control of Power Systems
E5 206	3:0	HV Power Apparatus
E5 209	3:0	OverVoltages in Power Systems
E6 211	3:0	Electric Drives

Project: 24 Credits
EP 299 0:24 Dissertation Project
Electives: The balance of credits to make up the minimum of 64 credits required to complete the MTech Degree Programme (all at the 200 level or higher).

MTech Programme Signal Processing
(Duration: 2 Years)
64 credits

Hard Core 12 Credits (All courses are compulsory)		
Course No.	Credits	Title of the Course
E1 244	3:0	Detection and Estimation Theory
E1 251	3:0	Linear and Nonlinear Optimization
E2 202	3:0	Random Processes
E2 212	3:0	Matrix Theory

Soft Core Minimum of 12 credits		
Course No.	Credits	Title of the Course
E1 213	3:1	Pattern Recognition and Neural Networks
E1 216	3:1	Computer Vision
E2 211	3:0	Digital Communication
E9 211	3:0	Adaptive Signal Processing
E9 221	3:0	Signal Quantization and Compression
E9 213	3:0	Time Frequency Analysis
E9 241	2:1	Digital Image Processing
E9 261	3:1	Speech Information Processing
E9 291	2:1	DSP System Design

Project: 28 Credits
EP 299 0:28 Dissertation Project
Electives: The balance of credits to make up the minimum of 64 credits required to complete the MTech Degree Programme (all at the 200 level or higher).

MTech Programme in Systems Engineering
(Duration: 2 Years)
64 credits

I Hard Core 13 Credits		
Course No.	Credits	Title of the Course
E0 251	3:1	Data Structures and Algorithms
E1 222	3:0	Stochastic Models and Applications
E1 241	3:0	Dynamics of Linear Systems
E1 251	3:0	Linear and Nonlinear Optimization

II Soft Core Minimum of 12 Credits		
Course No.	Credits	Title of the Course
E0 219	3:1	Linear Algebra and Applications
E0 223	3:1	Automated Verification
E0 235	3:1	Cryptography
E0 241	3:1	Computer Communication Networks
E0 246	3:1	Real-Time Systems
E0 268	3:1	Data Mining
E0 270	3:1	Machine Learning
E1 213	3:1	Pattern Recognition and Neural Networks
E1 216	3:1	Computer Vision
E1 244	3:0	Detection and Estimation Theory
E1 254	3:1	Game Theory
E2 212	3:0	Matrix Theory
E9 201 *	3:0	Digital Signal Processing
E9 241	2:1	Digital Image Processing
E9 261	3:1	Speech Information Processing

*(Above Course is recommended only for those who have not gone through a formal course)

Project: 24 Credits

EP 299 0:24 Dissertation Project

Electives: The balance of credits to make up the minimum of 64 credits required to complete the MTech Degree Programme (all at the 200 level or higher).

Dept of Computer Science and Automation

E0 312 (AUG) 3:1

Foundations of Secure Computation

Indistinguishability, real-ideal world and simulation-based security notions; Secret Sharing, Verifiable Secret Sharing, Oblivious Transfer, Circuit Garbling and function encoding, Commitment Scheme, Zero-knowledge Proof, Threshold Cryptography, Encryptions, Broadcast Byzantine Agreement, Coin-tossing protocol, Theoretical and practical protocols for secure computation in various models.

References:

Book: “Efficient Two-part Protocols- Techniques and Constructions” by Carmit Hazay and Yehuda Lindell.
Book Draft: “Secure Multiparty Computation and Secret Sharing - An Information Theoretic Appoach” by Ronald Cramer, Ivan Damgaard and Jesper Buus Nielsen.
Recent Research Papers

Arpita Patra

Mathematical maturity.,Basic level crypto course.,none

E0 227 (AUG) 3:1

Program Analysis and Verification

Dataflow analysis: Lattices, computing join-over-all-paths information as the least solution to a set of equations that model the program statements, termination of dataflow analysis, analysis of multi-procedure programs. Abstract interpretation of programs: Galois connections, correctness of dataflow analysis. Pointer analysis of imperative programs. Program dependence graphs, and program slicing. Assertional reasoning using Hoare logic. Type Systems: Monomorphic and polymorphic type systems, Hindley-Milner's type inference algorithm for functional programs.References:

Flemming Nielson, Hanne Riis Nielson, and Chris Hankin: Principles of Program Analysis, Springer, (Corrected 2nd printing, 452 pages, ISBN 3-540-65410-0), 2005.
Benjamic Pierce: Types and Programming Languages, Prentice-Hall India, 2002.
Research papers

Deepak DSouza, Raghavan K V

Pre-requisites: Exposure to programming,and the basics of mathematical logic and discrete structures.

E0 254 (AUG) 3:1

Network and Distributed Systems Security

Security Goals and Violations; Security Requirements; Security Services; Discrete Logs, Encryption/Decryption Functions, Hash Functions, MAC Functions; Requirements and Algorithmic Implementation of One-Way Functions; OS Security Violations and Techniques to Prevent Them; Access Control Models; Secure Programming Techniques; Authenticated Diffie-Hellman Key Establishment Protocols; Group Key Establishment Protocols; Block Ciphers and Stream Ciphers;

Modes of Encryption; Digital Signatures; Authentication Protocols; Nonce and Timestamps; PKI and X.509 Authentication Service; BAN logic; Kerberos; E-mail Security; IP Security; Secure Socket Layer and Transport Layer Security; Secure Electronic Transactions; Intrusion Detection; Malicious Software Detection;Firewalls.

References:

William Stallings: Cryptography and Network Security: Principles and Practices, Fourth Edition, Prentice Hall, 2006. Neil Daswani, Christoph Kern and Anita Kesavan: Foundations of Security: What Every Programmer Needs to Know, Published by Apress, 2007. Yang Xiao and Yi Pan: Security in Distributed and Networking Systems, World Scientific, 2007. Current Literature.

Ramesh Chandra Hansdah

Knowledge of Java is desirable,but not necessary.,none,none

E0 224 (AUG) 3:1

Computational Complexity Theory

Computational complexity theory is the fundamental subject of classifying computational problems based on their `complexities'. In this context, `complexity' of a problem is a measure of the amount of resource (time/space/random bits, or queries) used by the best possible algorithm that solves the problem. The aim of this course is to give a basic introduction to this field. Starting with the basic definitions and properties, we intend to cover some of the classical results and proof techniques of complexity theory. Introduction to basic complexity classes; notion of `reductions' and `completeness'; time hierarchy theorem & Ladner's theorem; space bounded computation; polynomial time hierarchy; Boolean circuit complexity; complexity of randomized computation; probabilistically checkable proofs; complexity of counting.

References:

The book titled `Computational Complexity - A Modern Approach' by Sanjeev Arora and Boaz Barak.

Lecture notes of similar courses as and when required.

Chandan Saha

Undergraduate level data structures & algorithms.,some mathematical maturity with an inclination towards theoretical computer science.,None

E0 210 (AUG) 3:1

Dynamic Program Analysis : Algorithms and Tools

Motivation and objectives of the course: The design and implementation of scalable, reliable and secure software systems is critical for many modern applications. Numerous program analyses are designed to aid the programmer in building such systems and significant advances have been made in recent years. The objective of the course includes introduction of the practical issues associated with programming for modern applications, the algorithms underlying these analyses, and applicability of these approaches to large systems. There will be special emphasis on practical issues found in modern software. The course project will be geared towards building the programming skills required for implementing large software systems.

Syllabus:

The course will introduce the students to the following topics -- bytecode instrumentation; profiling -- BL profiling, profiling in the presence of loops, preferential path profiling, memory profiling; software bloat; lock-free data structures; memoization; map-reduce programming model; approximate computing; multithreading; fuzzing techniques; record and replay; memory models; data races -- lockset algorithm, happens-before relation, causally-precedes relation; atomicity violations; deadlocks; linearizability; symbolic execution; concolic testing; directed program synthesis; constraint solving; deterministic/stable multithreaded systems; floating-point problems; security -- sql-injection, cross-site scripting, return-oriented programming, obfuscation; malware detection.

References:

Course material available from the webpage; research papers

Gopinath K

Basic knowledge of programming in C/C++/Java.,none,none

E0 267 (AUG) 3:1

Soft Computing

To introduce the student to the soft computing paradigm as compared to hard computing. To make them learn the techniques of soft computing like neural networks, fuzzy and rough systems, evolutionary algorithms etc. which can be applied to the task of classification, clustering, and other applications. Definition of soft computing, Soft computing vs. Hard computing; Advantages of soft computing, tools and techniques;Neural Networks : Fundamentals, backpropogation, associative memory, self organizing feature maps, applications;Fuzzy and rough sets : Concepts and applications; Evolutionary algorithms, swarm intelligence, particle swarm optimization, ant colony optimization, applications;Hybrid systems : Integration of neural networks, fuzzy logic and genetic algorithms, integration of genetic algorithms and particle swarm optimization, Applications.

References:

Timothy J.Ross, "Fuzzy Logic with Engineering Applications", McGraw-Hill,1997
David E.Goldberg,Genetic Algorithms in Search, Optimization, and Machine Learning, Pearson Education, 2009.
Melanie Mitchell, An introduction to genetic algorithms, Prentice Hall, 1998. 4. S. Haykin, Neural Networks?, Pearson Education, 2ed, 2001
Z. Pawlak, Rough Sets, Kluwer Academic Publisher, 1991.

Susheela Devi V

E0 271 (AUG) 3:1

Graphics and Visualization

Graphics pipeline; transformations; viewing; lighting and shading; texture mapping; modeling; geometry processing - meshing, multi-resolution methods, geometric data structures; visualization - visualization pipeline, data reconstruction, isosurfaces, volume rendering, flow visualization.

Vijay Natarajan

References: Edward S. Angel and Dave Shreiner. Interactive Computer Graphics: A Top-Down Approach with Shader-Based OpenGL. Pearson,2011. Dave Shreiner,Graham Sellers,John Kessenich,and Bill Licea-Kane. OpenGL Programming Guide: The Official Guide to Learning OpenGL. Addison-Wesley

E0 261 (AUG) 3:1

Database Management Systems

Design of Database Kernels, Query Optimization, Query Processing, Data Access Methods, Transaction Management, Distributed Databases, Data Mining, Data Warehousing, Main-Memory Databases, Columnar Databases, NoSQL systems.

References:

Database Systems Concepts, H. Korth, A. Silberschatz and S. Sudarshan, McGraw-Hill
Fundamentals of Database Systems R. Elmasri and S. B. Navathe, Addison-Wesley.
Database Management Systems R. Ramakrishnan and J. Gehrke, McGraw-Hill.
Readings in Database Systems M. Stonebraker and J. Hellerstein, Morgan Kaufmann.
Recent Conference and Journal papers.

Jayant R Haritsa

Data Structures,C or C++,Undergraduate course in DBMS,none,none

E0 334 (AUG) 3:1

Deep Learning for Natural Language Processing

Introduction, Multilayer Neural Networks, Back-propagation, Training Deep Networks; Simple word vector representations: word2vec, GloVe; sentence, paragraph and document, representations. Recurrent Neural Networks; Convolutional Networks and Recursive Neural Networks; GRUs and LSTMs; building attention models; memory networks for language understanding. Design and Applications of Deep Nets to Language Modeling, parsing, sentiment analysis, machine translation etc.

References:

Ian Goodfellow , Yoshua Bengio and Aaron Courville. Deep Learning. MIT Press, 2016

Recent Literature.

Shirish Krishnaji Shevade

A course on Machine Learning or equivalent

E0 256 (AUG) 3:1

Theory and Practice of Computer Systems Security

This course will seek to equip students with the fundamental principles and practice of computer systems security. The course will cover the major techniques of offense and defense, thereby educating students to think both as attackers and defenders. By the end of the course, students will have been exposed to the state of the art, and will be equipped with the background to start conducting original research in computer systems security. Core concepts such as basic security goals, threat models, notion of TCB and security policies vs. mechanisms. Operating system primitives for protection, reference monitors, authentication, and authorization. Examples of classic security policies from the literature (e.g., Biba, BLP) and their realization on modern systems. Various forms of hijacking attacks, such as buffer overflows, return-oriented programming, and non-control data attacks, and examples of such attacks as used by exploits in the wild. Design and implementation of defenses such as control-flow integrity, ASLR, privilege separation, capabilities, information-flow control and virtual machine introspection. Attacks and defenses against the Web ecosystem, mobile devices and the cloud platform. Emerging role of modern hardware in improving systems security. Other assorted topics based on current research literature.

References:

Security Engineering, 2nd Edition, Wiley, by Ross Anderson. http://www.cl.cam.ac.uk/~rja14/book.html (free online copy) Research papers from systems security conferences and journals.

Vinod Ganapathy

None,but standard undergraduate-level exposure to OS,computer architecture and compilers courses will be assumed.,none,none

E0 225 (AUG) 3:1

Design and Analysis of Algorithms

Greedy algorithms, divide and conquer strategies, dynamic programming, max flow algorithms and applications, randomized algorithms, linear programming algorithms and applications, NP-hardness, approximation algorithms, streaming algorithms.

References:
Kleinberg and Tardos, Algorithm Design, Addison Wesley, 2005.
Cormen, Leiserson, Rivest, and Stein, Introduction to Algorithms, 3rd Edition, Prentice Hall, 2009.

Siddharth Barman

none,none,none

E0 251 (AUG) 3:1

Data Structures and Algorithms

Abstract data types and data structures, Classes and objects, Complexity of algorithms: worst case, average case, and amoritized complexity. Algorithm analysis. Algorithm Design Paradigms. Lists: stacks, queues, implementation, garbage collection. Dictionaries: Hash tables, Binary search trees, AVL trees, Red-Black trees, Splay trees, Skip-lists, B-Trees. Priority queues. Graphs: Shortest path algorithms, minimal spanning tree algorithms, depth-first and breadth-first search. Sorting: Advanced sorting methods and their analysis, lower bound on complexity, order statistics.

References:

A.V. Aho, J.E. Hopcroft, and J.D. Ullman, Data Structures and Algorithms, Addison Wesley, Reading Massachusetts, USA, 1983 T.H. Cormen, C.E. Leiserson, and R.L. Rivest, Introduction to Algorithms, The MIT Press, Cambridge, Massachusetts, USA, 1990 M.A. Weiss, Data Structures and Algorithms Analysis in C++, Benjamin/Cummins, Redwood City, California, USA, 1994.

Srikant Y N

A.V. Aho,J.E. Hopcroft,and J.D. Ullman,Data Structures and Algorithms,Addison Wesley

E0 220 (AUG) 3:1

Graph Theory

Vertex cover, matching, path cover, connectivity, hamiltonicity, edge colouring, vertex colouring, list colouring; Planarity, Perfect graphs; other special classes of graphs; Random graphs, Network flows, Introduction to Graph minor theory

Sunil Chandran L

Reinhard Diestel,"Graph Theory",Springer (2010)~Douglas B. West,"Introduction to Graph Theory",Prentice Hall (2001)~A. Bondy and U. S. R. Murty B. Bollabas, "Modern Graph Theory", Springer (1998)

E0 243 (AUG) 3:1

Computer architecture

Processor Architecture: Instruction-Level Parallelism,Superscalar and VLIW architecture; Multi-core processors;Memory Subsystem: Multilevel caches, Caches in multi-core processors,Memory controllers for multi-core systems;Multiple processor systems: shared and distributed memory system,memory consistency models, cache coherence, and Interconnection networks;Advanced topics in architecture.

Arkaprava Basu

Hennessy~J.L.~and Patterson~D.A.: Computer Architecture~A quantitative Approach Morgan Kaufmann.,Stone,H.S.: High-Performance Computer Architecture,Addison-Wesley.,Current literature

E0 226 (AUG) 3:1

Linear Algebra and Probability

Linear Algebra: System of Linear Equations, Vector Spaces, Linear Transformations, Matrices, Polynomials, Determinants, Elementary Canonical Forms, Inner Product Spaces, Orthogonality. Probability: Probability Spaces, Random Variables, Expectation and Moment generating functions, Inequalities, Some Special Distributions. Limits of sequence of random variables, Introduction to Statistics, Hypothesis testing.

Narasimha Murty M, Shalabh Bhatnagar

References : Gilbert Strang,Linear Algebra and its Applications,Thomson-Brooks/ Cole,4th edition,2006.~Hoffman and Kunze

E0 235 (AUG) 3:1

Cryptography

Elementary number theory, Finite fields, Arithmetic and algebraic algorithms, Secret key and public key cryptography, Pseudo random bit generators, Block and stream ciphers, Hash functions and message digests, Public key encryption, Probabilistic encryption, Authentication, Digital signatures, Zero knowledge interactive protocols, Elliptic curve cryptosystems, Formal verification, Cryptanalysis, Hard problems.

References:

Stinson. D. Cryptography: Theory and Practice. Menezes. A. et. al. Handbook of Applied Cryptography

Sanjit Chatterjee, Arpita Patra

None,None,None

0 312 (AUG) 3:0

RBCCPS: Robot Dynamics and Control

General Description: This graduate will explore the dynamics and control of robots, both from a foundational level together with a view toward application. In particular, the course will first build the necessary mathematical framework in which to understand dynamic robotic systems, including: mathematical modeling, rigid body transformations, forward and inverse kinematics, dynamics and control, path planning, and Lyapunov stability for robots. Hybrid dynamical systems will be introduced as means to model walking robots, and the extension of continuous nonlinear dynamic and control concepts to a hybrid setting will be discussed

Shalabh Bhatnagar

Murray, Li and Sastry, A Mathematical Intruduction to Robot Manipulation, CRC Press, 1994,Spong, Hutchinson and Vidyasagar Robot Modeling and Control, Wiley, 2005,H. Khali, Nonlinear Systems, 3rd Edition, Prentice Hall, 2002,Supplemental Texts: A. Ghosal, Robotics: Fundamental Concepts and Analysis, Oxford, 2006. S. Sastry, Nonlinear Systems: Analysis, Stability and Control, Springer, 1999

E0 248 (JAN) 3:1

Theoretical Foundations of Cryptography

This course is a complexity-theoretic introduction to Cryptography. Emphasis will be placed on exploring connections between various fundamental cryptographic primitives via reductions.

Some of the primitives we will cover are one-way functions, pseudo-random generators, pseudo-random functions, trapdoor permutations, encryption, digital signatures, hash functions, commitments. We will also try to cover some special topics (private information retrieval, zero-knowledge proofs, oblivious transfer etc.).

Bhavana Kanukurthi

None,None,None

E0 249 (JAN) 3:1

Approximation Algorithms

Combinatorial algorithms: greedy algorithms, local search based algorithms; Linear programming based algorithms: randomized rounding, primal-dual schema based algorithms, iterated rounding; multicut, sparsest cut and metric embeddings; Semidefinite programming based algorithms; Hardness of approximation.

References:

"The Design of Approximation Algorithms" by David Shmoys and David Williamson".
"Approximation Algorithms" by Vijay Vazirani.

Anand Louis

E0225: Design and Analysis of Algorithms.

E0 305 (JAN) 3:1

Blockchain and its Applications

Motivation and objectives of the course: Blockchains and its applications in cryptography that include cryptocurrencies are emerging technologies. This course will cover blockchains and their applications to cryptocurrencies such as Bitcoin, distributed consensus and multiparty computation (MPC), smart contracts and beyond.

Syllabus:

a) Introduction to Blockchain and its cryptographic building blocks; (b) Blockchain Analysis (c) Introduction to Cryptocurrencies, Bitcoin and its alternative cryptocurrencies (d) Applications of Blockchains beyond cryptocurrencies (such as in consensus, multi-party computation (MPC), smart contracts); (e) Alternatives of Blockchains.

References:

Bitcoin and Cryptocurrency Technologies: A Comprehensive Introduction by Arvind Narayanan, Joseph Bonneau, Edward W. Felten, Andrew Miller, Steven Goldfeder and Jeremy Clark. Princeton University Press, 2016.
Mastering Bitcoins: Unlocking Digital Cryptocurrencies by Andreas Antonopoulos. O'Reilly Media, Inc, 2013.
Recent research papers and reports.

Arpita Patra

Mathematical maturity will be assumed.

E0 306 (JAN) 3:1

Deep learning: theory and practice

Motivation and objectives of the course: The area of deep learning has been making rapid empirical advances, however this success is largely guided by intuition and trial and error and remains more of an art than science. We lack theory that applies "end-to-end." While the traditional theory of machine learning leaves much to be desired, current research to remedy this is very active. Besides being of interest in its own right, progress on theory has the potential to further improve the current deep learning methods. This course will bring students up to date to the current fast-moving frontier. Along with theory topics the empirical phenomena that the theory seeks to explain will be covered in detail. The course will involve both theory and programming assignments.

Syllabus:

Tentative list of topics (subject to change depending on class interests, new developments in the field etc.): Quick introduction/reminder of deep learning and the theory of machine learning and optimization; Expressive power of neural nets; Landscape of deep learning optimization; Generalization in deep learning; Architectures (e.g. convolutional networks), network compression; Adversarial examples; Formal verification and neural networks; Visualization and interpretation; Deep generative models; Recurrent neural networks; Deep reinforcement learning

References:

Deep Learning by Ian Goodfellow, Yoshua Bengio, Aaron Courville
Understanding Machine Learning: From Theory to Algorithms by Shai Shalev-Shwartz, Shai Ben-David
Relevant recent literature

Anand Louis

Linear Algebra, Probability. Courses in ML, DL, Optimization and some prior familiarity with Python and deep learning frameworks such as PyTorch/TensorFlow will be useful, though not an absolute requirement.

E0 309 (JAN) 3:1

Topics in complexity theory

The theme of this course in the Jan-Apr 2015 semester is arithmetic circuit complexity. Arithmetic circuits are algebraic analogue of boolean circuits that naturally compute multivariate polynomials. The quest for a thorough understanding of the power and limitation of the model of arithmetic circuits (and its connection to boolean circuits) has lead researchers to several intriguing structural, lower bound and algorithmic results. These results have bolstered our knowledge by providing crucial insights into the nature of arithmetic circuits. Still, many of the fundamental questions/problems on arithmetic circuits have remained open till date.The aim of this course is to provide an introduction to this area of computational complexity theory. We plan to discuss several classical and contemporary results and learn about a wealth of mathematical (particularly, algebraic and combinatorial) techniques that form the heart of this subject.

References:

Current literature on Arithmetic circuit complexity.

Chandan Saha

Familiarity with basic abstract algebra, linear algebra, probability theory and algorithms will be helpful. More importantly, we expect some mathematical maturity with an inclination towards theoretical computer science.

E0 338 (JAN) 3:1

Topics in Security and Privacy

Recent technological advances in diverse domians such as CPS/IoT, cloud storage and computation, quantum information processing as well as proliferation of tools for digital mass surveillance have thrown up many interesting research problems. This course will focus on some of the theoretical questions in Security and Privacy from a cryptographic perspective. We plan to cover a subset of the following topics:(A) Cryptographic Security in a Post-Quantum World.(B) Design and Analysis of Privacy Enhancing Tools.(C) Efficient, Secure and Verifiable Query Processing in Outsourced Database.(D) Cryptocurrency, Smart Contracts, Blockchain and Applications.

References:

Recent research papers in the relevant areas.

Sanjit Chatterjee

Good perfomance in E0 235 (Cryptography) and consent of the instructor.

E0 343 (JAN) 3:1

Topics in Architecture

Architecture and harware description languages (RTL, ISPS, vhdl). Processor architecture, Instruction level parallelism, Latency tolerance, multithreading, interconnection networks, Standards (bus, SCI), architectures, routing, Cache coherency, protocol specification, correctness, performance. Memory consistency models, synchronization primitives, parallel programming paradigms, I/O systems, Interface standards, parallel I/O, performance evaluation, analytical methods, simulation algorithms and techniques, benchmarking.

Matthew Jacob T

Prerequisites Computer Architecture,Operating Systems,Some Familiarity with Analytical Performance Evaluation Techniques.,None,None

E0 244 (JAN) 3:1

Computational Geometry and Topology

Voronoi diagram, Delaunay triangulation, Geometric Data Structures — Interval tree, Range tree, Segment tree. Complexes — simplicial complex, Rips complex, alpha complex, homology, Betti numbers, persistence homology, Morse functions, Reeb graph, approximation and fixed parameter algorithms for geometric problems - hitting set and set cover, epsilon nets, epsilon approximations, geometric intersection graphs, geometric discrepancy, clustering.

Vijay Natarajan, Sathish Govindarajan

References: Computational Topology : An Introduction, Herbert Edelsbrunner and John L. Harer, American Mathematical Society, Indian Edition, 2010. Computational Geometry: Algorithms and Applications, Mark de Berg, Otfried Cheong, Marc van Kreveld, and Mark Overmars, Third Edition, Springer (SIE), 2011. Geometric Approximation Algorithms, Sariel Har-Peled, American Mathematical Society, Indian Edition, 2013.~Prerequisites: E0225 : Design and Analysis of Algorithms,None,None

E0 264 (JAN) 3:1

Distributed Computing Systems

Fundamental Issues in Distributed Systems, Distributed System Models and Architectures; Classification of Failures in Distributed Systems, Basic Techniques for Handling Faults in Distributed Systems; Logical Clocks and Virtual Time; Physical Clocks and Clock Synchronization Algorithms; Security Issues in Clock Synchronization; Secure RPC and Group Communication; Group Membership Protocols and Security Issues in Group Membership Problems; Naming Service and Security Issues in Naming Service; Distributed Mutual Exclusion and Coordination Algorithms; Leader Election; Global State, Termination and Distributed Deadlock Detection Algorithms; Distributed Scheduling and Load Balancing; Distributed File Systems and Distributed Shared Memory; Secure Distributed File Systems; Distributed Commit and Recovery Protocols; Security

Issues in Commit Protocols; Checkpointing and Recovery Protocols; Secure Checkpointing; Fault-Tolerant Systems, Tolerating Crash and Omission Failures; Implications of Security Issues in Distributed Consensus and Agreement Protocols; Replicated Data Management; Self-Stabilizing Systems; Design Issues in Specialized Distributed Systems.

References:

Randy Chow, and Theodore Johnson, "Distributed Operating Systems and Algorithms", Addison-Wesley, 1997. Sukumar Ghosh, "Distributed Systems: An Algorithmic Approach", CRC Press, 2006. Kenneth P. Birman, "Reliable Distributed Systems: Technologies, Web Services, and Applications", Springer New York, 2005 G. Coulouris, J. Dollimore, and T. Kindberg, "Distributed Systems: Concepts and Designs", Fourth Edition, Pearson Education Ltd., 2005. Current Literature

Ramesh Chandra Hansdah

Prerequisites NDSS(E0 254) or equivalent course,None,None

E0 238 (JAN) 3:1

Artificial Intelligence

Introduction to Artificial Intelligence, Problem solving, knowledge and reasoning, Logic, Inference, Knowledge based systems, reasoning with uncertain information, Planning and making decisions, Learning, Distributed AI, Communication, Web based agents, Negotiating agents, Artificial Intelligence Applications and Programming.

References:

S. Russel and P. Norvig, Artificial Intelligence - A Modern Approach, Prentice Hall, 1995.
George F. Luger, Artificial Intelligence, Pearson Education, 2001.
Nils J. Nilsson, Artificial Intelligence - A New Synthesis, Morgan Kaufmann Publishers, 2000

Susheela Devi V

None,None,None

E0 268 (JAN) 3:1

Practical Data Science

Introduction, Data Preparation, Linear Methods for Classification and Regression, Additive Models and Tree based methods, Support Vector Machines, Model Assessment and Selection, Unsupervised Learning, Link Analysis, Recommendation Systems and Handling Large Datasets: MapReduce.

References:

James, Witten, Hastie and Tibshirani, An Introduction to Statistical Learning with Applications in R, Springer, 2015 Rajaraman, Leskovec and Ullman, Mining of Massive Datasets, Cambridge University Press, 2014Hastie, Tibshirani and Friedman, The Elements of Statistical Learning, Springer, 2009 Recent literature

Shirish Krishnaji Shevade

Prerequisites Linear Algebra, Probability and Statistics, Some programming experience in any language.,None,None

E0 235 (JAN) 3:1

Cryptography

Elementary number theory, Finite fields, Arithmetic and algebraic algorithms, Secret key and public key cryptography, Pseudo random bit generators, Block and stream ciphers, Hash functions and message digests, Public key encryption, Probabilistic encryption, Authentication, Digital signatures, Zero knowledge interactive protocols, Elliptic curve cryptosystems, Formal verification, Cryptanalysis, Hard problems.

References:

Stinson. D. Cryptography: Theory and Practice.
Menezes. A. et. al. Handbook of Applied Cryptography

Sanjit Chatterjee, Arpita Patra

None,None,None

E1 313 (JAN) 3:1

Topics in Pattern Recognition

Foundations of pattern recognition. Soft computing paradigms for classification and clustering. Knowledge-based clustering. Association rules and frequent itemsets for pattern recognition. Large-scale pattern recognition.

References:

R. O. Duda, P. E. Hart, and D.G. Stork, Pattern Classification, John Wiley & Sons (Asia), Singapore, 2002 Recent Literature.

Narasimha Murty M

None,None,None

E0 320 (JAN) 3:1

Topics in Graph Theory

Minors: Introduction - properties which causes dense minors in graphs: average degree, girth, Wagner's characterisation of graphs without K5 minors. Tree Decompositions: treewidth, pathwidth, upper and lower bounds for treewidth, relation of treewidth and minors, influence on algorithmic graph problems. Hadwiger's conjecture - its relation with the four colour theorem, related work.

References:

Graph Theory (Chapters 8 and 12), Reinhard Diestel, Springer, 2000. Current Literature

Sunil Chandran L

None,None,None

E0 255 (JAN) 3:1

Compiler Design

Control flow graphs and analysis; Dataflow analysis; Static single assignment (SSA); Compiler optimizations; Dependence analysis, Loop optimizations and transformations, Parallelization, Optimizations for cache locality, and Vectorization; Domain-specific languages, compilation, and optimization; Register allocation, Instruction scheduling; Run time environment and storage management; Impact of language design and architecture evolution on compilers.

References:

Aho, A.V., Ravi Sethi and J.D. Ullman: Compilers - Principles, Techniques and Tools, Addison Wesley, 1988.S. Muchnick: Advanced Compiler Design and Implementation, Morgan Kauffman, 1998
Selected Papers.

Srikant Y N

None,None,None

E0 272 (JAN) 3:1

Formal Methods in Software Engineering

Domain modeling using first-order predicate logic and relational calculus -- the tools Alloy and Event-B. Verification of finite-state systems, and concurrent systems -- Spin. Verifying code correctness using logical reasoning -- VCC. Testing and bounded-exploration of applications -- Pex andAFL.

References:

Logic in Computer Science: Modelling and Reasoning about Systems, by Michael Huth and Mark Ryan. Software Abstractions: Logic, Language, and Analysis, by Daniel Jackson. Model Checking, by Edmund M. Clarke, Orna Grumberg, and Doron Peled. Specifying software: A Hands-On Introduction, by R. D. Tennent. Research papers.

Deepak DSouza, Raghavan K V

Prerequisites Exposure to programming,and the basics of mathematical logic and discrete structures.,None,None

E0 202 (JAN) 3:1

Automated Software Engineering with Machine Learning

Engineering high-quality software requires mastering advanced programming concepts, and dealing with large and complex code. This course will introduce program analysis and machine/deep learning techniques to help developers in this quest. It will focus on concurrency and security analysis of smartphone and web applications. There is growing realization in the software community that we can learn useful program properties from large codebases by treating code as data, and augmenting program analysis with machine learning. This course will introduce machine/deep learning techniques to build probabilistic models of source code, and discuss how they can be used to solve novel problems in software engineering. Programming Language Processing: tokenization, parsing and semantic analysis, graph representations, syntactic transformations. Smartphone and Web Programming: multi-threading, asynchronous event-handling, permissions. Program Analysis: static and dynamic analysis of concurrent programs, model checking, information flow analysis for security, random testing. Probabilistic Models of Source Code: program embeddings, probabilistic grammars, statistical language models, structural models. Applications of Machine Learning (e.g., code completion, software testing and debugging).

References:

Zigurd Mednieks and Laird Dornin and G. Blake Meike and Masumi Nakamura. Programming Android. O'Reilly, 2011.David Harman. Effective JavaScript. Addison-Wesley, 2012. Steve Souders. Even Faster Websites. O'Reilly, 2009. Ian Goodfellow and Yoshua Bengio and Aaron Courville. Deep Learning. MIT Press, 2016

Research papers.

Aditya Sunil Kanade

None,None,None

E0 337 (JAN) 3:1

Topics in Advanced Cryptography

The goal of this course is to focus on cutting-edge research themes in cryptography and understand the mathematical objects and/or computational assumptions behind them. Advanced encryption schemes such as, for example, CCA secure encryption, circular secure encryption, searchable encryption, fully-homomorphic encryption and their underlying computational assumptions (LWE etc.). Other advanced topics such as puncturable PRFs, obfuscation, multilinear maps.

Bhavana Kanukurthi

Prerequisites A course in Cryptography and mathematical maturity.,None,None

E0 203 (JAN) 3:1

Spectral Algorithms

Spectral graph algorithms are very popular in theoretical computer science and machine learning, as they provide polynomial time approximations to several hard computational problems. This course will cover some basic topics in spectral graph theory and algorithms with some applications to network analysis. This course emphasizes rigorous analysis of algorithms. Overview of Linear Algebra and Matrix theory, Perron-Frobenius theory, Rayleigh Ratios, Laplacians, Spectral graph partitioning algorithm, Cheeger?s inequal- ity, Davis-Kahan theorem and perturbation analysis, Community detection in networks and stochastic block models, SVD, Mixture Models, Probabilistic spectral clustering, Recursive spectral clustering, optimization via low-rank approximation.

References:

Fan Chung, Spectral Graph Theory, AMS 1997. Ravindran Kannan, Santosh Vempala, Spectral Algorithms, NOW Publishers, 2009. Andries E. Brouwer, Willem H. Haemers, Spectra of graphs, Springer 2011.

Ambedkar Dukkipati, Anand Louis

Prerequisites Any course in Linear Algebra or Matrix Theory.,None,None

E0 361 (JAN) 3:1

Topics in Database Systems

Object-oriented Databases, Distributed and Parallel Databases, Multi-databases, Access Methods, Transaction Management, Query Processing, Deductive Databases, multimedia Databases, Real-Time Databases, Active Databases, Temporal Databases, Mobile Databases, Database Benchmarks, Database Security, Data Mining and Data Warehousing.

References:

Readings in Database Systems edited by M. Stonebraker, Morgan Kaufmann, 2nd ed., 1994.
Conference and Journal papers

Jayant R Haritsa

None,None,None

E0 270 (JAN) 3:1

Machine Learning

Introduction to machine learning. Classification: nearest neighbour, decision trees, perceptron, support vector machines, VC-dimension. Regression: linear least squares regression, support vector regression. Additional learning problems: multiclass classification, ordinal regression, ranking. Ensemble methods: boosting. Probabilistic models: classification, regression, mixture models (unconditional and conditional), parameter estimation, EM algorithm. Beyond IID, directed graphical models: hidden Markov models, Bayesian networks. Beyond IID, undirected graphical models: Markov random fields, conditional random fields. Learning and inference in Bayesian networks and MRFs: parameter estimation, exact inference (variable elimination, belief propagation), approximate inference (loopy belief propagation, sampling). Additional topics: semi-supervised learning, active learning, structured prediction.

References:

Bishop. C M, Pattern Recognition and Machine Learning. Springer, 2006.
Duda, R O, Hart P E and Stork D G. Pattern Classification. Wiley-Interscience, 2nd Edition, 2000.
Hastie T, Tibshirani R and Friedman J, The Elements of Statistical Learning: Data Mining, Inference and Prediction. Springer, 2nd Edition, 2009.
Mitchell T, Machine Learning. McGraw Hill, 1997.
Current literature.

Ambedkar Dukkipati

Prerequisites Probability and Statistics (or equivalent course elsewhere). Some background in linear algebra and optimization will be helpful.,None,None

E0 322 (JAN) 3:1

Topics in Algebra and Computation

The course will consist of two parts: Computational aspects of algebra & number theory ; Use of algebraic methods in theoretical computer science. Part 1: Chinese remaindering, Discrete Fourier Transform, Resultant of polynomials, Hensel lifting, Automorphisms of rings, Short vectors in Lattices, Smooth numbers etc. - and show how these tools are used to design algorithms for certain fundamental problems like integer & polynomial factoring, integer & matrix multiplication, fast linear algebra, root finding, primality testing, discrete logarithm etc. Part 2: This will deal with certain applications of algebraic methods/algorithms in cryptography (RSA cryptosystem, Diffie-Hellman), coding theory (Reed-Solomon & Reed-Muller codes, locally decodable codes), analysis of boolean functions (Fourier analysis), and construction of expander graphs.

References:

Modern Computer Algebra by von zur Gathen and Gerhard. Introduction to Finite Fields by Lidl & Niederreiter.

Relevant research papers and online lecture notes.

Chandan Saha

Prerequisites Basic familiarity with linear algebra and properties of finite fields (as in the Chapter 1-3 of the book 'Introduction to finite fields and their applications' by Rudolf Lidl and Harald Niederreiter). Alternatively,an undergraduate course in algebra. Most importantly,some mathematical maturity with an inclination towards theoretical computer science.,None,None

E0 304 (JAN) 3:1

Computational Cognitive Neuroscience

This reading course is focused on recent advances computational frameworks in cognitive neuroscience. We will review the state-of-the art in data analysis techniques that permit extracting meaningful information from noisy, high-dimensional brain data (e.g. machine learning and dimensionality reduction) as well as theoretical and computational models of brain function. The course will be organized into four reading modules on Machine learning and classification, Dimensionality reduction, Neural computation and Theory, and Deep convolutional neural networks, discussing recent applications in computational neuroscience. The project will require analyzing large-scale brain datasets, for example, decoding cognitive states from brain imaging data.

Sridharan Devarajan

Familiarity with machine learning,dimensionality reduction,and linear algebra at the advanced undergraduate/early graduate level.,Knowledge of coding (e.g. C/Matlab/Python) is essential.,Some background in neuroscience is preferred

E1 254 (JAN) 3:1

Game Theory

Introduction: rationality, intelligence, common knowledge, von Neumann - Morgenstern utilities; Noncooperative Game Theory: strategic form games, dominant strategy equilibria, pure strategy nash equilibrium, mixed strategy Nash equilibrium, existence of Nash equilibrium, computation of Nash equilibrium, matrix games, minimax theorem, extensive form games, subgame perfect equilibrium, games with incomplete information, Bayesian games. Mechanism Design: Social choice functions and properties, incentive compatibility, revelation theorem, Gibbard-Satterthwaite Theorem, Arrow's impossibility theorem, Vickrey-Clarke-Groves mechanisms, dAGVA mechanisms, Revenue equivalence theorem, optimal auctions. Cooperative Game Theory: Correlated equilibrium,

two person bargaining problem, coalitional games, The core, The Shapley value, other solution concepts in cooperative game theory
.

References:

Roger B. Myerson, Game Theory: Analysis of Conflict, Harvard University Press, September 1997. Martin J. Osborne, An Introduction to Game Theory, Oxford University Press, 2003. Y. Narahari, Dinesh Garg, Ramasuri Narayanam, Hastagiri Prakash. Game Theoretic Problems in Network Economics and Mechanism Design Solutions. Springer, 2009.

Narahari Y, Siddharth Barman

E1 246 (JAN) 3:1

Natural Language Understanding

Syntax: syntactic processing; linguistics; parts-of-speech; grammar and parsing; ambiguity resolution; tree adjoint grammars. Semantics: semantic interpretation; word sense disambiguation; logical form; scoping noun phrases; anaphora resolution. Pragmatics: context and world knowledge; knowledge representation and reasoning;local discourse context and reference; discourse structure; semantic web; dialogue; natural language understanding and generation. Cognitive aspects: mental models, language acquisition, language and thought; theories of verbal field cognition. Applications: text summarization, machine translation, sentiment analysis, perception evaluation, cognitive assistive systems; NLP tool-kits augmentation.

References:

Allen J, Natural language understanding, Pearson Education, 1995, 2003. Jurafsky D, and Martin J H, Speech and language processing: an introduction to natural language processing, computational linguistics and speech recognition, Pearson Education, 2000, 2003. Posner M I, Foundations of Cognitive Science, MIT Press, 1998. Research Literature.

Partha Pratim Talukdar

Prerequisites Familiarity with programming (optionally including scripting languages); data structures, algorithms and discrete structures; reasonable knowledge of English language.,None,None

E1 396 (JAN) 3:0

Topics in Stochastic Approximation Algorithms

Introduction to Stochastic approximation algorithms, ordinary differential equation based convergence analysis, stability of iterates, multi-timescale stochastic approximation, asynchronous update algorithms, gradient search based techniques, topics in stochastic control, infinite horizon discounted and long run average cost criteria, algorithms for reinforcement learning.

References:

H.J.Kushner and G.Yin, Stochastic approximation and recursive algorithms and applications (2nd edition), Springer Verlag, New York, 2003.

A.Benveniste, M.Metiview and P.Priouret, Adaptive algorithms and stochastic approximation, Springer-Verlag,1990.

V.S.Borkar,Stochastic Approximation: A Dynamical Systems Viewpoint, Hindustan Book Agency, 2008.
D.P.Bertsekas and J.N.Tsitsiklis, Neuro-dynamic programming, Athena Scientific, 1996.
Relevant research papers

Shalabh Bhatnagar

Prerequisites A basic course on probability theory and stochastic processes,None,None

E0 253 (JAN) 3:1

Operating Systems

User Level Specification of OS. Fundamental Concepts of Multiprogrammed OS, Basic Concepts and Techniques for Implementation of Multiprogrammed OS. Processes and the Kernel, Microkernel Architecture of OS. Multiprocessor, Multimedia, and Real-Time OS. POSIX Standards. Management and Control of Processes. Basic Concept of Threads, Types of Threads, Models of Thread Implementations. Traditional and Real-Time Signals. Clocks, Timers and Callouts. Thread Scheduling for Unix, Windows, and Real-Time OS, Real-Time Scheduling. Interprocess/Interthread Synchronization and Communication, Mutual Exclusion/Critical Section Problem, Semaphores, Monitors, Mailbox, Deadlocks. Concepts and Implementation of Virtual Memory(32-bit and 64-bit), Physical Memory Management. File Organization, File System Interface and Virtual File Systems, Implementation of File Systems. I/O Software:Interrupt Service Routines and Device Drivers. Protection and Security. Case Study of Unix, Windows, and Real-Time OS.

References:

Andrew S. Tanenbaum: Modern Operating Systems, Second Edition, Pearson Education, Inc., 2001.
Uresh Vahalia: UNIX Internals: The New Frontiers, Prentice-Hall, 1996.
J. Mauro and R. McDougall: Solaris Internals: Core Kernel Architecture, Sun Microsystems Press, 2001.
Daniel P. Bovet and Marco Cesati: Understanding the Linux kernel, 2nd Edition O'Reilly & Associates, Inc., 2003.

Vinod Ganapathy, Arkaprava Basu

None,None,None

E1 277 (JAN) 3:1

Reinforcement Learning

Shalabh Bhatnagar

EP 299 (JAN) 0:24

Project

This includes the analysis, design of hardware/software, construction of an apparatus/Instrument and testing and evaluation of its performance. Usually, the project work is based on a scientific/engineering problem of current interest. And every student has to complete the work in the specified period and should submit the Project Report for final evaluation.

Satish L

Dept of Electrical Communication Engineering

E2 221 (AUG) 3:0

Communication Networks

Introduction to networking. TCP and UDP, TCP analysis. IP, optimal routing, algorithms for shortest path routing, routing protocols, Mobile IP. ARQ schemes and analysis, random access, random/slotted ALOHA, splitting algorithms, CSMA-CD, wireless LANs CSMA/CA, IEEE 802.11 MAC. Modelling and performance analysis in networks; deterministic analysis, scheduling; stochastic analysis - traffic models, performance measures, Little's Theorem, M/G/1 model, Priority queueing.

Chockalingam A

A. Kumar, D. Manjunath, and J. Kuri, Communication Networking: An Analytical Approach, Morgan Kaufman Publishers, 2004.,D. Bertsekas and R. Gallager, Data Networks, 2nd Edition, Prentice-Hall India, 2002.,J. F. Kurose and K. W. Ross, Computer Networking: A Top-Down Approach Featuring the Internet, Pearson Education Asia, 2001.

E2 211 (AUG) 3:0

Digital Communication

Representation of signals and systems; Digital modulation techniques and their performance in AWGN channel; optimum receiver structures for AWGN channel; signal design for band-limited and power-limited channels; power and bandwidth efficiency tradeoff; coding and coded modulation techniques – capacity approaching schemes; ISI and equalization; Multichannel and multicarrier systems; Digital communications through fading multipath channels.

Sundar Rajan B

S. Haykin,Digital Communication Wiley 1999.,J. G. Proakis,Digital Communication,4th edition

E2 208 (AUG) 3:0

Topics in Information Theory & Coding

Topics will be drawn from codes for distributed storage, low-density parity-check codes, polar codes and multi-terminal information theory, network-error correcting codes, distributed function computation, network security, interference alignment and index coding.

Sundar Rajan B

T. Cover and J.A. Thomas,,Elements of Information Theory, John Wiley, (2nd Edition), 2006.,R.W. Yeung, Information Theory and Network Coding, Springer, 2008.

E9 211 (AUG) 3:0

Adaptive Signal Processing

Review of estimation theory. Wiener Solution. Kalman filter and its application to estimation, filtering and prediction. Iterative solution; of method of steepest descent and its convergence criteria, least mean square gradient algorithm (LMS), criteria for convergence and LMS versions: normalized

LMS, leaky, sign, variable stepsize, transform domain LMS algorithm using DFT and DCT. Block LMS (BLMS) algorithm: frequency domain BLMS (FBLMS). Recursive least square (RLS) method, fast transversal, fast lattice RLS and affine projection algorithms. Applications of adaptive filtering: spectral estimation, system identification, noise cancelling acoustic and line echo cancellation, channel equalization.

Hari K V S

References:,Ali H Sayed,Adaptive Filters, John Wiley/IEEE, 2008

E0 259 (AUG) 3:1

Data Analytics

This course will be taught jointly by Professors Rajesh Sundaresan and Ramesh Hariharan.

Data Analytics is assuming increasing importance in recent times. Several industries are now built around the use of data for decision making. Several research areas too, genomics and neuroscience being notable examples, are increasingly focused on large-scale data generation rather than small-scale experimentation to generate initial hypotheses. This brings about a need for data analytics. This course will develop modern statistical tools and modelling techniques through hands-on data analysis in a variety of application domains. The course will illustrate the principles of hands-on data analytics through several case studies (8-10 such studies). On each topic, we will introduce a scientific question and discuss why it should be addressed. Next, we will present the available data, how it was collected, etc. We will then discuss models, provide analyses, and finally touch upon how to address the scientific question using the analyses. Data sets from astronomy, genomics, visual neuroscience, sports, speech recognition, computational linguistics and social networks will be analysed in this course. Statistical tools and modeling techniques will be introduced as needed to analyse the data and eventually address these scientific questions.

Prerequisites:

Random Processes (E2 202) or Probability and Statistics (E0 232) or equivalent.

Ramesh Hariharan, Rajesh Sundaresan

Random Processes (E2 202),or Probability and Statistics (E0 232),or equivalent

E2 205 (AUG) 3:0

Error-Control Coding

Basics of binary block codes; mathematical preliminaries: groups, rings, fields and vector spaces; convolutional codes and the Viterbi algorithm; belief propagation with application to the decoding of codes; LDPC codes; finite fields, Reed-Solomon and BCH codes.

Navin Kashyap

R.M. Roth,Introduction to Coding Theory,Cambridge University Press,2006~T. Richardson and R. Urbanke,Modern Coding Theory

E2 201 (AUG) 3:0

Information Theory

Entropy, mutual information, data compression, channel capacity, differential entropy, Gaussian channel.

Himanshu Tyagi

T. M. Cover and J. A. Thomas,Elements of Information Theory,2nd edition,,John Wiley & Sons

E3 238 (AUG) 2:1

Analog VLSI Circuits

Review of MOS device characteristics, Long channel MOS, Second order effects, MOS small signal parameters and models, MOS capacitance. Concept of fT, Bipolar transistors, Small signal parameters of BJTs, Common Emitter/Common source Amplifiers, CB/CG Amplifiers Emitter/Source followers, Source Degeneration, Cascodes, emitter/Source coupled pairs, Current Mirrors, Differential Pairs, Frequency Response, Noise, Feedback, Linearity, Operational Amplifiers: Telescopic and Folded Cascode, Stability and Compensation, Slew rate and setting, Common Mode Feedback

Gaurab Banerjee

Behzad Razavi, Design of Analog CMOS Integrated Circuits,Grey, Hurst, Lewis and Meyer, Analysis and Design of Analog Integrated Circuits,Selected Papers and Patents

E2 202 (AUG) 3:0

Random Processes

The axioms of probability theory, continuity of probability, independence and conditional probability, random variables and their distribution, functions of a random variable, expectation, jointly distributed random variables, conditional distribution and expectation, Gaussian random vectors.

Convergence of sequences of random variables, Borel-Cantelli Lemma, laws of large numbers and central limit theorem for sequences of independent random variables, Chernoff bound.

Definition of a random process, stationarity. Correlation functions of random processes in linear systems, power spectral density.

Discrete time Markov chains, recurrence analysis, Foster's theorem, continuous time Markov chains, the Poisson process, simple Markovian queues.

Utpal Mukherji, Parimal Parag

B. Hajek, An Exploration of Random Processes for Engineers, Course Notes, 2009,A. Kumar, Discrete Event Stochastic Processes, Online book.,Geoffrey Grimmett and David Stirzaker, Probability and Random Processes, 3rd edition, 2001

E2 251 (AUG) 3:0

Communications Systems Design

Communication link design for AWGN channels; path loss models, noise figure, receiver sensitivity; link budget for deep space communication - a case study. Communication subsystem requirements and specifications: analog/digital front-end, oscillator phase noise, analog/digital up/down conversion, carrier frequency offset (CFO), bandpass sampling, DAC/ADC interface, quantization noise and clipping, dynamic range, ADC selection, automatic gain control (AGC), sampling jitter, CORDIC, I/Q imbalance, DC offset correction, error vector magnitude (EVM), power amplifier (PA) non-linearities. Communication link budget for flat fading channels - a case study. * Communication link budget for ISI channels - multi-carrier (OFDM) and single-carrier (cyclic-prefixed SC) techniques; impact of PA distortions in OFDM, PAPR issues, CFO estimation and correction, SFO estimation and correction. Communication link budget for MIMO wireless and spatial modulation – a case study. Visible light wireless communications (VLC); transmitter, channel, receiver, performance, MIMO-VLC.

Chockalingam A

Tony J. Rouphael, ``Wireless Receiver Architectures and Design:,Antenna, RF, Synthesizers, Mixed Signal and Digital,Signal Processing,'' Academic Press, 2014,Lydi Smaini, ``RF Analog Impairments Modeling for Communication Systems Simulation: Application to OFDM-based Transceivers,'' John-Wiley & Sons, 2012.,Abbas Mohammadi and Fadhel M. Ghannouchi, ``RF Transceiver Design for MIMO Wireless Communications,'' Springer-Verlag, 2012. Fa-Long Luo, ``Digital Front-End in Wireless Communications and Broadcasting: Circuits and Signal Processing,'' Cambridge Univ. Press, 2011. Research papers

E9 206 (AUG) 3:0

Digital Video: Perception and Algorithms

The course will cover algorithms for digital video processing from the point of view of human visual perception. Topics include video sampling, frequency response of human visual systems, color perception, video transforms, retinal and cortical filters (difference of Gaussians, Laplacian of Gaussians, center-surround responses, 3D Gabor filterbanks, steerable pyramids), motion detection, Reichardt detector, optical flow algorithms (Horn-Schunck, Black-Anandan, Fleet-Jepson, optical flow in the brain, block motion), video compression, statistical video models (spectrum power law, divisive normalization, Gaussian scale mixtures, optical flow statistics, Weber-Fechner law), video quality assessment, stereopsis, denoising, foveation and saliency.

Rajiv Soundararajan

A. C. Bovik,Al Bovik's Lecture Notes on Digital Video,The University of Texas at Austin,2017.,M. Tekalp

E3 220 (AUG) 3:0

Foundations of Nanoelectronic Devices

Mathematical foundations of quantum mechanics, operators, bra and ket algebra, time independent and time dependent Schrodinger equation, crystal lattice and Brillouin zone, Bloch theorem, band theory of solids, tight binding, band structure examples (Si, Ge, III-V) in E-k space, effective mass, principles of operation of p-n junction (homo and hetero junction) and MOSFET, single gate versus multiple gates, bound states, effect of confinement, subbands, quantum capacitance, strain effects, tunneling, tunnel diode, intra-band and band to band tunneling in MOSFET, quantum theory of linear harmonic oscillators, phonons in solids, carrier mobility in MOSFET, quantum theory of angular momentum, electron spin.

Kausik Majumdar

D. J. Griffiths, Introduction of Quantum Mechanics, Prentice Hall.,A. Ghatak and S. Lokanathan, Quantum Mechanics, Trinity Press.,V. K. Thankappan, Quantum Mechanics, New Age. Solid State Physics, N. W. Ashcroft and N. D. Mermin.,S. M. Sze, Physics of Semiconductor devices, Wiley-Interscience.,Y. Taur and T. H. Ning, Fundamentals of modern VLSI devices, Cambridge University Press~A. Ghatak and S. Lokanathan, Quantum Mechanics, Trinity Press~V. K. Thankappan, Quantum Mechanics, New Age~N. W. Ashcroft and N. D. Mermin, Solid State Physics, Cenage Learning~S. M. Sze, Physics of Semiconductor devices, Wiley-Interscience

E7 221 (AUG) 2:1

Fiber-Optic Communication

Introduction to fiber optics; light propagation. Optical fibers; modes, dispersion, low, nonlinear effects; Optical transmitters: LEDs, Semiconductor Lasers, Transmitter design; Optical receivers: Photodetectors, Receiver design, Noise, sensitivity; System design and performance: voice, video, data transmission, analog and digital systems, standards;

Broadband local area optical networks and WDM systems; coherent communication systems; long distance telecommunications using optical amplifiers and solitons. Introduction to topics of current interest: all optical networks, integrated optics, MOEMS; microwave photonics. Experiments on characteristics of optical fibers, sources and detectors, analog and digital link, WDM system, tutorial on optical fiber system design, simulation of optical fiber modes.

Shivaleela E S, Srinivas T

A. Selvarajan,S. Kar and T. Srinivas,Optical Fiber Communications,Principles and Systems,Tata – Mc Graw Hill

E8 202 (AUG) 2:1

Computational Electromagnetics

Maxwell's equations, Wave equations, scalar and vector potentials, fundamental theorems in EM Method of moments: Greens Functions; Surface equivalence principle; Electrostatic formulation; Magnetostatic formulation; Electric Field Integral Equation; Magnetic Field Integral Equation; Direct and Iterative Solvers; Finite difference time domain methods: 1D wave propagation, yee Algorithm, Numerical dispersion and stability, Perfectly matched absorbing boundary conditions, Dispersive materials. Antenna and scattering problems with FDTD, non-uniform grids, conformal grids, periodic structures, RF circuitAdvanced topics in numerical electromagnetics based on recent literature About the courseThe course will have programming assignments (using Matlab/Fortran/C++).

Vinoy K J, Dipanjan Gope

A. Taflove and SC Hagness Computational Electrodynamics: The Finite Difference Time Domain Method, 3ed Ed., Artech House,Andrew F. Peterson, Scott L. Ray, Raj Mittra: Computational Methods for Electromagnetics, 1st Ed., IEEE Press Series on Electromagnetic Wave Theory,Walton C. Gibson: The Method of Moments in Electromagnetics, 1st Ed., Chapman and Hall,Roger F. Harrington: Field Computation by Moment Methods, 1993, Wiley-IEEE Press

E2 331 (AUG) 3:0

Advanced Topics in Coding Theory

This course will start with the basics of error-correcting codes and go on to cover specific classes of codes. The classes of codes will be drawn from: codes for distributed storage, LDPC codes, cyclic (algebraic) codes.

Vijay Kumar P

linear algebra (matrix theory),and probability theory,,at a graduate or at least, senior undergraduate level.

E1 245 (AUG) 3:0

Online Prediction and Learning

Online classification, Regret Minimization, Learning with experts, Online convex optimization, Multi-armed bandits, Applications- sequential investment/portfolio selection, universal lossless data compression, Stochastic games- Blackwell approachability, Learning systems with state- online reinforcement learning

Aditya Gopalan

A basic course on probability or random processes,Prediction, Learning and Games. Nicolo Cesa-Bianchi and Gabor Lugosi, Cambridge University Press, 2006,Online Learning and Online Convex Optimization. Shai Shalev-Shwartz. Foundations and Trends in Machine Learning Vol. 4, No. 2 (2011) 107–194, DOI: 10.1561/2200000018,Regret Analysis of Stochastic and Nonstochastic Multi-armed Bandit Problems. Sebastien Bubeck and Nicolo Cesa-Bianchi. Foundations and Trends in Machine Learning Vol. 5, No. 1 (2012) 1-122, DOI: 10.1561/2200000024

E2 214 (AUG) 3:0

Finite – State Channels

Basic definitions; information-theoretic capacity and channel coding theorems; the Gilbert-Elliott channel; memoryless channels with input constraints; feedback capacity and its dynamic programming formulation; posterior matching schemes for achieving feedback capacity

Navin Kashyap

Pre-requisites: E2 201 (Information theory),R.G. Gallager, Information Theory and Reliable Communication, Wiley, 1968,Journal papers

E1 396 (AUG) 3:0

Topics in Stochastic Approximation Algorithms

Introduction to Stochastic approximation algorithms, ordinary differential equation based convergence analysis, stability of iterates, multi-timescale stochastic approximation, asynchronous update algorithms, gradient search based techniques, topics in stochastic control, infinite horizon discounted and long run average cost criteria, algorithms for reinforcement learning.

References:

1. H.J.Kushner and G.Yin, Stochastic approximation and recursive algorithms and applications (2nd edition), Springer Verlag, New York, 2003.

2. A.Benveniste, M.Metiview and P.Priouret, Adaptive algorithms and stochastic approximation, Springer-Verlag,1990.

3. V.S.Borkar,Stochastic Approximation: A Dynamical Systems Viewpoint, Hindustan Book Agency, 2008.

4. D.P.Bertsekas and J.N.Tsitsiklis, Neuro-dynamic programming, Athena Scientific, 1996.

5. Relevant research papers.

Prerequisites:
Random Processes (E2 202) or Probability and Statistics (E0 232) or equivalent

Rajesh Sundaresan

Random Processes (E2 202) or Probability and Statistics (E0 232) or equivalent~none~none

E2 336 (AUG) 3:0

Foundations of Machine Learning

Parimal Parag

Foundations of machine learning, Mehryar Mohri, Afshin Rostamizadeh, and Ameet Talwalkar,Understanding Machine Learning, Shai Shalev-Shwartz and Shai Ben-David

E2 334 (JAN) 3:0

Topics in Computation over Networks

Parimal Parag

Information, Physics, and Computation, Mezard, Montanari,Random graphs and complex networks, Remco van der Hofstad,Factor Graphs and the Sum-Product Algorithm, Frank Kschischang, Brendan J. Frey, Hans-Andrea Leliger, Transactions on Information Theory, Vol 47, no. 2, 2001

E2 330 (JAN) 3:0

Statistical Physics Methods in Information Theory and Coding

The aim of the course is to introduce a range of tools, tricks and jargon from statistical physics that are useful in information and coding theory. The topics to be covered in the course are: The basic statistical physics models: Lattice gas, Ising, spin glasses; formulation of inference problems as spin glass models Exactly solvable models: Curie-Weiss, and Ising on a tree Message passing algorithms: Belief propagation and variants, approximate message passing Partition functions and their computation

Navin Kashyap

Pre-requisites: E2 205 (Error-Correcting Codes) References: - Nicolas Macris and Rudiger Urbanke (2017), Statistical Physics for Communications, Signal Processing and Computer Science, lecture notes for course at EPFL (latest available version). - Marc Mezard and Andrea Montanari (2009), Information, Physics and Computation, Oxford Univ. Press. - Hidetoshi Nishimori (2001), Statistical Physics of Spin Glasses and Information Processing: An Introduction, Oxford Univ. Press. - Selected journal papers

E2 203 (JAN) 3:0

Wireless Communication

Wireless channel modeling; diversity techniques to combat fading; cellular communication systems, multiple-access and interference management; capacity of wireless channels; opportunistic communication and multiuser diversity; MIMO – channel modeling, capacity and transmit and receiver architectures; OFDM.

Neelesh B Mehta

D. Tse and P. Viswanath,,"Fundamentals of Wireless Communication", Cambridge University Press, 2005.,A. Goldsmith, "Wireless Communication," Cambridge University Press, 2005.

E2 214 (JAN) 3:0

Finite – State Channels

Basic definitions; information-theoretic capacity and channel coding theorems; the Gilbert-Elliott channel; memoryless channels with input constraints; feedback capacity and its dynamic programming formulation; posterior matching schemes for achieving feedback capacity

Navin Kashyap

Pre-requisites: E2 201 (Information theory),R.G. Gallager, Information Theory and Reliable Communication, Wiley, 1968.,Selected journal papers.

E2 331 (JAN) 3:0

Advanced Course in Coding Theory

This course will start with the basics of error-correcting codes and go on to cover specific classes of codes. The classes of codes will be drawn from: codes for distributed storage, LDPC codes, cyclic (algebraic) codes.

Vijay Kumar P

linear algebra (matrix theory),and probability theory,,at a graduate or at least, senior undergraduate level.

E1 244 (JAN) 3:0

Detection and Estimation Theory

Hypothesis testing, Neyman-Pearson theorem, likelihood ratio test and generalized likelihood ratio test, uniformly most powerful test, multiple-decision problems, detection of deterministic and random signals in Gaussian noise, detection in non-Gaussian noise, sequential detection, introduction to nonparametric testing. Parameter Estimation: Unbiasedness, consistency, Cramer-Rao bound, sufficient statistics, Rao-Blackwell theorem, best linear unbiased estimation, maximum likelihood estimation. Bayesian estimation: MMSE and MAP estimators, Wiener filter, Kalman filter, Levinson-Durbin and innovation algorithms.

Aditya Gopalan

H. V. Poor,,An Introduction to Signal Detection and Estimation,Springer-Verlag, 2nd edition, 1994

E2 204 (JAN) 3:0

Stochastic Processes and Queueing Theory

Basic mathematical modeling is at the heart of engineering. In both electrical and computer engineering, many complex systems are modeled using stochastic processes. This course will introduce students to basic stochastic processes tools that can be utilized for performance analysis and stochastic modeling. Detailed study of processes encountered in various stochastic dynamic systems, such as branching, counting, urns, infections, and queues.

Course content: Poisson process, Renewal theory, Markov chains, Reversibility, Queueing networks, Martingales, Random walk.

Vinod Sharma

S. M. Ross, Stochastic Processes, Wiley, 2nd Edition, 1996.,E. Cinlar, Introduction to Stochastic processes, Prentice Hall, 1975.,P. Bremaud, Markov Chains: Gibbs Fields, Monte Carlo Simulation, and Queues, Springer, 1999.,J. R. Norris, Markov Chains, Cambridge, 1998.,F. P. Kelly, Reversibility and Stochastic Networks, Cambridge, 2011.

E2 209 (JAN) 3:0

Topics in Information Theory & Statistical Learning

This course will cover the basics of, and some recent advances in, the use of information theoretic techniques in statistical learning. The following topics will be covered:

Hypothesis testing and minimax estimation; maximum likelihood estimation; asymptotic optimality; local asymptotic normality; sample optimal testing and estimation (uniformity testing, equality testing, independence testing, missing mass estimation, support estimation, learning Gaussian mixtures); information criteria for model selection (AIC, BIC, MDL); topics in nonparametric estimation.

Himanshu Tyagi

The course will be based largely on research papers, but the following reference books will be used.,Devroye, L., Györfi, L., and Lugosi, G, "A Probabilistic Theory of Pattern Recognition." Springer-Verlag, New York (1996).,Devroye, L. and Lugosi, G, "Combinatorial methods in density estimation." Springer-Verlag, New York (1996).,P. D. Grünwald, The Minimum Description Length Principle. MIT Press (2007).

E3 237 (JAN) 3:0

Integrated Circuits for Wireless Communication

Wireless transceiver SNR calculations, modulation techniques, linearity and noise, receiver and transmitter Architectures, passive RF networks, design of active building blocks: low noise amplifiers, mixers, power amplifiers, VCOs, phase locked loops and frequency synthesizers, device models for RF design, mm-wave and THz communication systems

Gaurab Banerjee

Behzad Razavi, RF Microelectronics~Thomas Lee, The Design of CMOS RF Integrated Circuits~Relevant Journal and Conference Papers

E2 242 (JAN) 3:0

Multiuser Detection

Direct Sequence spread spectrum, spreading sequences and their correlation functions, near-far effect in DS-CDMA, error probability for DS-CDMA on AWGN channels, Multiuser Detection – MF detector, decorrelating detector, MMSE detector. Successive interference canceller, parallel interference canceller, linear PIC. Performance analysis of multiuser detectors and interference cancellers. Low complexity multiuser detectors for MIMO systems. Multiuser/MIMO detection using belief propagation, probabilistic data association, meta-heuristics, and Markov chain Monte carlo techniques. Spatial modulation index modulation for multiuser systems.

Chockalingam A

S. Verdu, Multiuser Detection, Cambridge Univ.Press, 1998.,A. Chockalingam and B. Sundar Rajan, Large MIMO Systems, Cambridge Univ.Press, February 2014.,H. Wymeersch, Iterative Receiver Design, Cambridge Univ. Press, 2007.,D. Tse and P. Viswanath, Fundamentals of Wireless Communication, Cambridge University Press, 2005,Research Papers in Journals and Conferences

E7 211 (JAN) 3:0

Photonics Integrated Circuits

Principles: Introduction to Photonics; optical waveguide theory; numerical techniques and simulation tools; photonic waveguide components – couplers, tapers, bends, gratings; electro-optic, acousto-optic, magneto-optic and non-linear optic effects; modulators, switches, polarizers, filters, resonators, optoelectronics integrated circuits; amplifiers, mux/demux, transmit receive modules;

Technology: materials – glass, lithium niobate, silicon, compound semiconductors, polymers; fabrication – lithography, ion-exchange, deposition, diffusion; process and device characterization; packaging and environmental issues;

Applications: photonic switch matrices; planar lightwave circuits, delay line circuits for antenna arrays, circuits for smart optical sensors; optical signal processing and computing; micro-opto-electro-mechanical systems; photonic bandgap structures; VLSI photonics

Srinivas T, Varun Raghunathan

C. R. Pollock and M. Lip Son, Integrated Photonics, Kluwer Pub., 2003.,T. Tamir, (ed), Guided-wave optoelectronics, (2nd edition), Springer-Verlag, 1990,H. Nishihara, M. Haruna, and T. Suhara, Optical Integrated Circuits, McGraw-Hill, 1988,E. J. Murphy, (Editor), Integrated Optical Circuits and Components: Design and Applications, Marcel and Dekker, 1999.,Current literature: Special issues of journals and review articles

E7 231 (JAN) 3:0

Fiber-Optics Networks

Introduction to Fiber-optic networks; Components for optical networks; Broadcast and select networks; Wavelength routing networks; Virtual topology design; Control and Management; Access networks; Deployment considerations; Photonics switching; Recent developments and futuristic issues.

Shivaleela E S, Srinivas T

Prerequisite: E7 221 or equivalent,R. Ramaswami and K. N. Sivarajan, Optical Networks: A practical Perspective, (2nd Ed), Morgan Kufmann Publishers 2002.,S. V. Kattalopoulos, Introduction to DWDM Technology, IEEE Press, 2000,Current literature: special issues of journals and review articles

E2 241 (JAN) 3:0

Wireless Networks

Macromodels for power attenuation in mobile wireless networks (path loss, shadowing, multipath fading). Link budget analysis. Cellular networks; FDM/TDM/TDMA: spatial reuse, cochannel interference analysis, cell sectoring, channel allocation (fixed and dynamic), handover analysis, Erlang capacity analysis. CDMA: interference analysis, other cell interference, hard and soft handovers, soft capacity, and Erlang capacity analysis; examples from GSM, IS95 and WCDMA networks. OFDMA: simple models for scheduling and resource allocation. Wireless random access networks: ALOHA, CSMA/CA; IEEE 802.11 WLANs and their analysis. Wireless ad hoc networks: links and random topologies, connectivity and capacity, scaling laws, scheduling in ad hoc networks; wireless ad hoc internets and sensor networks.

Utpal Mukherji

A. Kumar, D. Manjunath, and J. Kuri, Wireless Networking, Morgan Kaufman, 2008,G. L. Stuber, Principles of Mobile Communications, 2nd edition, Kluwer Academic Publishers, 2001,D. Tse and P. Viswanath, Fundamentals of Wireless Communication, Cambridge University Press, 2005.~none~none

E9 203 (JAN) 3:0

Compressed Sensing and Sparse Signal Processing

Introduction to Compressed Sensing. Basic theory: l1 minimization, null space property, necessary and sufficient conditions for l0 – l1 equivalence. Mutual coherence and the Restructed Isometry property, and their consequences. RIP and random matrices. Johnson-Lindenstrauss Lemma Stable signal recovery and the restricted eigenvalue property. Recovery algorithms and their performance guarantees. Special/advanced topics upon student request.

Hari K V S

Pre-requisite: Random Processes, Matrix Theory,M. Elad, “Sparse and Redundant Representations”, Sprinter, 2010.,H. Rauhut, “Compressive Sensing and Structured Random Matrices,” Radon Series Comp. Appl. Math., 2011.,R. Baranuik, M. A. Davenport, M. F. Duarte, C. Hegde, “An Introduction to Compressive Sensing,” Rice University Connextions Course, 2011.~none~none

E9 231 (JAN) 3:0

MIMO Signal Processing

In this course, we cover the theory, algorithms, and practical considerations in multiple-antenna adaptive wireless communication systems. The topics covered will include the useful results from information theory, parameter estimation theory, array processing, and wireless communications, all specialized to the case of advanced multiple-antenna adaptive processing. We will also discuss various design issues in ad hoc networks, cognitive radio, and MAC protocols for multiple antenna systems.

Chandra R Murthy

Daniel W. Bliss and Siddhartan Govindasamy, "Adaptive Wireless Communications: MIMO Channels and Networks,",Cambridge University Press, 2013,Xiaodong Wang and Vincent Poor, "Wireless Communication Systems: Advanced Techniques for Signal Reception," Prentice Hall Inc., 2004

E7 214 (JAN) 3:0

Optoelectronics Devices

This course is intended to be an introduction and bit more in-depth discussion into the field of semiconductor optoelectronics. This would be a good bridge between the microelectronic devices and photonics disciples offered at the Institute. The course would require some basic understanding of semiconductors and calculus at undergraduate level as a pre-requisite. The main topics which would be covered are as follows:

Quick refresher into semiconductor physics: band structures, doping, density of states, carrier concentration and p-n junctions. Optical transitions in semiconductors: different radiative and non-radiative processes, and rate calculations. Light emitters: LEDs and Lasers, diode structures, characteristics (LI curves, speed etc.), Lasing condition, hetero-structures, quantum wells, quantum dot lasers and VCSELs. Light detectors: Photodiodes, structure, biasing conditions, photovoltaic and photoconductive devices, solar cells, p-i-n and avalanche photodiodes, characteristics (responsitivity, gain and speed), and noise processes in detection. Light modulation: Electro-optic devices, amplitude and phase modulation, Franz-Keldysh effect, quantum confined stark effect. Review of current topics in optoelectronics: heterogeneously integrated lasers, thermo-photo voltaic devices, silicon photonics, Germanium lasers, SPASERS, Polariton lasers etc. 3-4 homeworks, one midterm, one final and a group project are intended as means of evaluating the students.

Varun Raghunathan

Suitable textbooks and reference books for this course are as follows: B.E.A. Saleh and M.C. Teich, "Fundamentals of Photonics," Wiley, 2nd edition, ISBN: 978-0-471-35832-9.,J.M. Liu, "Photonic devices," Cambridge University Press, 1st edition, ISBN: 978-0-521-55859-4.,P. Battacharya, "Semiconductor optoelectronic devices," Pearson Education, 2nd edition, ISBN: 978-8177581669.,S.L. Chuang, "Physics of Photonic devices," Wiley-Blackwell, 2nd edition, ISBN: 978-0470293195.

E8 242 (JAN) 2:1

Radio Frequency Integrated Circuits and Systems

Introduction to wireless systems, personal communication systems, High frequency effects in circuits and systems. Review of EM Fundamentals and Transmission line Theory, terminated transmission lines, smith chart, impedance matching, Microstrip and Coplanar waveguide implementations, microwave network analysis, ABCD parameters, S parameters. Behavior of passive IC components and networks, series and parallel RLC circuits, resonant structures using distributed transmission lines, components and interconnects at high frequencies Basics of high frequency amplifier design, biasing techniques, simultaneous tuning of 2 port circuits, noise and distortion. MEMS technologies and components for RF applications: RF MEMS switches, varactors, inductors and filters. Introduction to microwave antennas, definitions and basic principles of planar antennas. CRLH meta materials for microwave circuits and components.

Course will have a Lab component involving design, fabrication and testing of some basic passive circuits and antennas with Industry Standard Softwares.

Vinoy K J

D M Pozar, Microwave Engineering, John Wiley 2003,D M Pozar., Microwave and RF Wireless Systems,T H Lee., The design of CMOS Radio Frequency Integrated Circuits,V K Varadan., K. J Vinoy., K.A Jose., RF MEMS and Their Applications

E9 262 (JAN) 3:0

Stochastic Models for Language, Speech and Audio

Human speech communication, concept=> signal=> concept & levels of information. Discrete and continuous representations, signal representation as a pattern; structure representation through lexicon, grammar. ASR: text recognition, speaker recognition, language identification, keyword spotting. Gaussian models and Bayesian inference; maximum likelihood parameter estimation.

Mixture Gaussian models, EM algorithm derivation; relation to K-means algorithm, LBG algorithm and EM generalization. Application to speaker-ID. Units of speech: linguistic, acoustic and stochastic; segmentation problem. Dynamic programming introduction. maximum-likelihood segmentation; segment clustering and automatic sub-word units. Graphical models and Markov models; Language modeling, N-grams and their estimation. Tree structured language model, minimum entropy decision tree algorithm; language perplexity measure. Application to spoken language-ID. Hidden Markov model (HMM): Markov structure for latent variables; Gaussian density, discrete density, mixture Gaussian and semi-continuous density models. HMM evaluation, training and decoding problems: forward-backward algorithm, Baum-Welch algorithm, Viterbi algorithm, segmental K-means (SKM) algorithm. HMM duration density and explicit duration modeling and modified EM algorithm. Finite state network (FSN) of HMMs and lexicon building. Continuous speech recognition (CSR) through FSN decoding using time-synchronous Viterbi algorithm. Viterbi beam search for large vocabulary CSR. Linear Dynamical Systems and kalman filtering, relation to HMM.

Sreenivas T V

Pre-requisite: E2-202 Random Processes or equivalent.,* X. Huang and A. Acero and H. Hon: "Spoken Language Processing," Prentice Hall, 2001 + Research papers,* C.M. Bishop: "Pattern Recognition and Machine learning," Springer, 2006.,* L.R. Rabiner and B.H. Juang: "Fundamentals of speech recognition," Prentice Hall, 1993.

E9 271 (JAN) 3:0

Space-Time Signal Processing and Coding

Multiple-Input Multiple-Output (MIMO) communication systems: Space-Time Code construction and decoding algorithms, Distributed space-time coding. Coding and signal processing for multi-way relay systems. Coding and algorithms for broadcast, multicast and interference channels. Simultaneous Wireless Information and Power Transfer (SWIPT) systems. Wireless Network Coding

Sundar Rajan B

Pre requisites: Digital Communication,Introduction to Space-Time Wireless Communications,,A. Paulraj, R. Nabar and D. Gore. Cambridge University Press, 2003. Current literature

E9 202 (JAN) 3:0

Advanced DSP Non-Linear Filters

Sreenivas T V

EP 299 (JAN) 0:16

Project

This includes the analysis, design of hardware/software, construction of an apparatus/Instrument and testing and evaluation of its performance. Usually, the project work is based on a scientific/engineering problem of current interest. And every student has to complete the work in the specified period and should submit the Project Report for final evaluation.

Satish L

Dept of Electrical Engineering

E1 222 (AUG) 3:0

Stochastic Models and Applications

Probability spaces, conditional probability, independence, random variables, distribution functions, multiple random variables and joint distributions, moments, characteristic functions and moment generating functions, conditional expectation, sequence of random variables and convergence concepts, law of large numbers, central limit theorem, stochastic processes, Markov chains, Poisson process.

Subbayya Sastry P

References: Ross S M,Introduction to Probability Models,(6th Edition),academic Press and Hardcourt Asia,2000.

E1 241 (AUG) 3:0

Dynamics of Linear Systems

Background material on matrix algebra, differential equations. Representation of dynamic systems, equilibrium points and linearization. Natural and forced response of state equations, state space descriptions, canonical realizations. Observability and controllability, minimal realization. Linear state variable feedback, stabilization, modal controllability, Jordan form, functions of matrices, pole-placement, Lyapunov matrix equations. Asymptotic observers, compensator design, and separation principle. Preliminary quadratic regulator theory.

Pavankumar Tallapragada

Panos J. Antsaklis,Anthony N. Mitchel,"Linear Systems",Birkhauser,1997

E0 332 (AUG) 3:0

Matrix Analysis

Matrix Analysis: Spectral theory of self-adjoint mappings, variational characterization of eigenvalues, perturbation theory for eigenvalues and eigenspaces of normal matrices, majorization and doubly stochastic matrices, numerical range of matrices, Perron-Frobenius theory, calculus of matrix-valued and vector-valued functions, and matrix inequalities.
Computations: Numerical algorithms for matrix factorizations, conditioning and stability, iterative solvers, Krylov subspace method, Arnoldi and Lancosz iterations, specialized Laplacian solvers, modern algorithms for parallel and randomized computations involving huge matrices.

Kunal Narayan Chaudhury

Prerequisites: Basic course on Linear Algebra/Matrix Theory.,References: Bellman R,Introduction to Matrix Analysis,SIAM,1987.

E0 247 (AUG) 3:1

Sensor Networks

Basic concepts and issues, survey of applications of sensor networks, homogeneous and heterogeneous sensor networks, topology control and clustering protocols, routing and transport protocols, access control techniques, location awareness and estimation, security information assurance protocols, data fusion and management techniques, query processing, energy efficiency issues, lifetime optimization, resource management schemes, task allocation methods, clock synchronization algorithms. A Wi-Fi application, Communication between MSP 430 based Sensor nodes and with addition of Extra Sensors. Compute Total Energy and estimated life of Battery.

Rathna G N

Pre-requisite: Consent of Instructor,References: Raghavendra C S,Shivalingam K M and Znati T,Wireless Sensor Networks,Springer

E9 291 (AUG) 2:1

DSP System Design

DSP Architecture: Single Core and Multicore; Pipelining and Parallel Processing; DSP algorithms: Convolution, Correlation, FIR/IIR filters, FFT, adaptive filters, sampling rate converters, DCT, Decimator, Expander and Filter Banks. DSP applications. Weekly laboratory exercises using Beagle and xilinx FPGA boards.

Rathna G N

References: Rulph Chassaing,Digital signal processing and applications with C6713 and C6416 DSK,Wiley,2005,Keshab K Parhi

E5 201 (AUG) 2:1

Production, Measurement,and Application of High Voltage

Generation of HV AC by cascade transformers, resonant circuit, Tesla coil; Generation of HV DC by Cockroft-Walton voltage multipliers; generation of high impulse voltages and currents, Methods of measurement of AC, DC and impulses voltages and currents, basic principles of electric breakdown in gaseous medium; basic aspects of EHV/UHV power transmission, and selected industrial applications of corona. Laboratory: Breakdown experiments on simple air-gaps, Chubb-Fortescue method of AC voltage measurement, Surface discharge demonstration, experiments on insulator strings including pollution flashover, measurement of high impulse voltage, Demonstration of space charge repulsion effect, radio-interference-voltage measurement, Demonstration of Impulse current heating effect.

Rajanikanth B S

References: Kuffel E~Zaengl W S~Kuffel J~High Voltage Engineering- Fundamentals~Newnes

E5 253 (AUG) 2:1

Dielectrics and Electrical Insulation Engineering

Joy Thomas M

E5 215 (AUG) 2:1

Pulsed Power Engineering

Joy Thomas M

E5 213 (JAN) 3:0

EHV/UHV Power Transmission Engineering

Joy Thomas M

E6 211 (JAN) 3:0

Electric Drives

Closed loop control of DC drives. Static inverters-Voltage source inverters, inverter control; six step and pulse width modulated operation, AC motor operation from inverters. Voltage source drives, closed loop control of AC drives.

Narayanan G

References: Ranganathan V T, Electric Drives, Course Notes, IISc, 2005-06,Fitzgerald A E , Kingsley C Jr. and Umans S D, Electric Machinery, Tata McGraw Hill, 2003. Leonhard W., Control of Electrical Drives, 3rd Edition, Springer,Miller T J E, Brushless Permanent-Magnet and Reluctance Motor Drives, Oxford Science Publications, 1989 Krishnan R, Permanent-Magnet-Synchronous and Brushless DC motor Drives, CRC Press, Taylor & Francis Group, 2010,Current Literature.

E1 216 (JAN) 3:1

Computer Vision

This course will present a broad, introductory survey intended to develop familiarity with the approaches to modeling and solving problems in computer vision. Mathematical modeling and algorithmic solutions for vision tasks will be emphasised. Image formation: camera geometry, radiometry, colour. Image features: points, lines, edges, contours, texture; Shape: object geometry, stereo, shape from cues; Motion: calibration, registration, multiview geometry, optical flow; approaches to grouping and segmentation; representation and methods for object recognition. Applications;

Srinivasa Venu Madhav Govindu

References: David Forsyth and Jean Ponce , Computer Vision: A Modern Approach, Prentice-Hall India, 2003,Hartley R and Zisserman A, Multiple View Geometry in Computer Vision, Second Edition, Cambridge University Press, 2004.,Current literature

E9 292 (JAN) 2:1

Real-Time Signal Processing with DSP

Implementation of discrete-time systems, DSP device architecture and programming (TMS320C6x), FIR/IIR digital filter design, Multirate DSP, Power spectrum estimation, Linear prediction and adaptive filtering, Real-time system development, DSP Programming, Code Composer Studio and DSP BIOS, Spawning and controlling tasks and data I/O, Real-time scheduling analysis, load analysis, Queues, semaphores and mailboxes, Real-time data exchange using Lab view, Mini Project.

Rathna G N

Pre-requisite: Knowledge of Digital Signal Processing,Nasser kehtarnawaz,Real-Time Digital Signal Processing based on TMS320C6000,TMS320C6x Data Sheets from TI

E4 233 (JAN) 3:0

Computer Control of Power Systems

State transition diagram, security-oriented functions, data acquisition, SCADA/EMS/WAMS system, state estimation, load forecasting, security assessment. Automatic Generation Control (AGC). Voltage stability assessment, reactive power/voltage control, security oriented economic load despatch, preventive and restorative controls. Unit committment, Hydrothermal Scheduling, Optimal power flow

Gurunath Gurrala

References: Wood A J, and Wallenberg B F, Power Generation, Operation and Control, John Wiley and Sons, 1984.,Russel B D, and Council M E, Power System Control and Protection, Academic press, 1978. Miller T J E, Reactive Power Control in Electrical Power System, John Wiley, USA.,Prabha Kundur, Power System Stability and Control, McGraw Hill Inc., 1983. Kusic G L, Computer Aided Power System Analysis, Prentice Hall of India Pvt. Ltd, 1989.

E5 206 (JAN) 3:0

HV Power Apparatus

HV power transformers, equivalent circuit, surge phenomenon, standing and traveling wave theory, ladder network representation, short circuit forces, impulse testing, diagnostics and condition monitoring of transformers, natural frequencies and its measurement, modern techniques. Introduction to HV switching devices, electric arcs, short circuit currents, TRV, CB types, air, oil and

SF6 CB, short circuit testing.

Satish L, Rajanikanth B S, Udaya Kumar

References: Bernard Hochart, Power Transformer Handbook, Butterworth, 1987.,The J & P Transformer Book, 12th Edn, M J Heathcote, Newnes, 1998. Transformers, Bharat Heavy Electricals Limited, Tata McGraw Hill, 2001.,Blume L F, and Boya Jian, Transformer Engineering, John Wiley and Sons, 1951. Garzon R D, HV Circuit Breakers – Design and Applications, Marcel and Dekker NY, 1996.,Flurscheim C H, Power Circuit Breaker: Theory and Design, Peter Peregrinus Ltd., 1975. Ryan H M, and Jones G R, SF6 Circuit Breaker, Peter Peregrinus Ltd., 1989.

E5 212 (JAN) 3:0

Computational Methods for Electrostatics

Laplace's and Poisson's equations in insulation design, transient fields due to finite conductivity, method of images, images in two-layer soil, numerical methods, finite difference, finite element and charge simulation methods tutorials and demonstration on PC. Programming assignments.

Udaya Kumar

References: Sadiku M N O, Numerical Techniques in Electromagnetics, Second Edn, CRC Press.,Weber E, Electromagnetic Fields, Dover, 1951. Silvester P P and Ferrari R L, Finite Elements for Electrical Engineers, Cambridge University Press, 1996.,Selected journal papers.

E5 209 (JAN) 3:0

Over voltages in Power Systems

Transient phenomena on transmission lines, methods of analysis and calculation, use of PSPICE, principle of EMTP lightning discharges, origin and characteristics of lightning and switching overvoltages, behaviour of apparatus and line insulation under overvoltages. Protection of Apparatus against Overvoltages, Surge arresters, VFTO in GIS, insulation co-ordination.

Satish L

References:,Ragaller K (ed.),Surges in High Voltage Networks,Plenum Press,1980.

E4 238 (JAN) 3:0

Advanced Power System Protection

Overview of over-current, directional, distance and differential, out-of-step; protection and fault studies; Service conditions and ratings of relays; Impact of CVT transients on protection; Current Transformer: accuracy classes, dynamic characteristics, impact and detection of saturation, choice for an application; Circuit Breaker: need for breaker failure protection, breaker failure protection schemes, design considerations for breaker failure protection; Transmission line protection: issues and influencing factors, definitions of short, medium and long lines using SIR, protection schemes, fault location identification techniques; Transformer protection: issues, differential protection of auto-transformers, two-winding, three-winding transformers, impact of inrush and over-excitation, application of negative sequence differential, protection issues in 'modern' transformers; Generator protection: issues, generating station arrangements, groundings, protection schemes; Bus protection: issues, bus configurations, protection zones, protection schemes; Overview of HVDC protection systems; Protection scheme for distributed generators (DGs); Special Protection Schemes (SPS); Power system protection testing; Common Format for Transient Data Exchange

(COMTRADE), Communication architecture for substation automation; Basics of synchrophasor based Wide Area Monitoring Systems (WAMS);

Sarasij Das

References: Horowitz. S.H. and A.G. Phadke, Power system relaying, by John Wiley & Sons, 3 rd edition 2008.,Mason C.R, The Art and Science of Protective relaying, GE Digital Energy Phadke A.G. and Thorp J.S. Synchronized Phasor Measurements and Their Applications, Springer, 2008,C37 series of IEEE standards on power system protection IEC 61850 - Communication Networks and Systems in Substations

E4 237 (JAN) 2:1

Selected Topics in Integrated Power Systems

Development of large power grids. Hierarchy of integrated power systems. Modelling of various types of series and shunt Flexible AC Transmission Systems (FACTS), phase shifters, multiple schemes of HVDC systems. Unbalanced system analysis and load balancing. Digital techniques for computation of very fast electro-magnetic transients, analysis of switching and fault transients in EHV/UHV systems. Wide Area Monitoring Systems (WAMS), placement of Phasor Measurement Units (PMUs), Phasor and Frequency Estimation, Enhanced State Estimation, observability analysis, Voltage Stability assessment and fault detection using Phasor Measurements.

Gurunath Gurrala

References: Current Literature,Phadke A G, Thorp J S, “Synchronized Phasor Measurements and Their Applications”, Springer, 2008 Acha E, “FACTS: modelling and simulation in power networks”, Wiley, 2004,Hingorani N G and Gyugyi, L and El-Hawary M, “Understanding FACTS: concepts and technology of flexible AC transmission systems”, IEEE press New York, 2000,Kundur P and Balu, N J and Lauby M G, “Power system stability and control”, McGraw-Hill, 1994 Miller T J E, “Reactive power control in electric systems”, Wiley-Interscience, 1982

E0 265 (JAN) 3:1

Convex Optimization and Applications

The focus of the course will be on the fundamental aspects of convex analysis and optimization, both in terms of theory and algorithms. We will also look at various applications of convex optimization in inverse problems, signal processing, image reconstruction, communications, statistics, and machine learning. In the process of understanding the foundations of various algorithms, the students will be introduced to relevant topics in convex analysis and duality.

Topics

Review of relevant topics in real analysis, linear algebra, and topology. Topics in convex analysis: convex sets and functions, analytical and topological properties, projection onto convex sets, hyperplanes, separation theorems, sub-gradients, etc. Duality and its applications: Optimality conditions, duality, minimax theory, saddle points, KKT conditions. Canonical programs for constrained optimization: Linear programming, cone programming, and semidefinite programming.Classical algorithms: simplex, ellipsoid, and interior-point methods. Modern algorithms: accelerated gradient methods, proximal methods, FISTA, forward-backward splitting, augmented Lagrangian, ADMM, etc.

Discussion of some of the popular applications of convex optimization.

Kunal Narayan Chaudhury

References: Boyd S and Vandenberghe L, Convex Optimization,Cambridge University Press, 2004.,Bertsekas D P, Convex Optimization Theory, Athena Scientific, 2009.,Bertsekas D P, Nonlinear Programming, Athena Scientific, 1999.

E5 213 (JAN) 3:0

EHV/UHV Power Transmission Engineering

Electrical power transmission by HVAC and HVDC, Overhead transmission lines, Bundled conductors, Mechanical vibration of conductors, Surface voltage gradient on conductors, Corona & associated power loss, Radio-noise and Audible-noise & their measurement, Fields under transmission lines, Overhead line insulators, Insulator performance in polluted environment, EHV cable transmission - underground cables and GIL, High Voltage substations-AIS and GIS, Grounding of towers and substations, Over voltages in power systems, Temporary, lightning and Switching over voltages, Design of line insulation for power frequency voltage, lightning and switching over voltages, Insulation Co-ordination.

Joy Thomas M

References: Begamudre R D, Extra High Voltage AC Transmission Engineering –Wiley Eastern Limited, 1990,Transmission line Reference Book 345 kV & above, Electrical Power Research Institute, (EPRI), 1982 USA. Journal Publications,Current literature from journals and conference proceedings.

E0 246 (JAN) 3:1

Real - time Systems

Hard and soft real-time systems, deadlines and timing constraints, workload parameters, periodic task model, precedence constraints and data dependency, real time scheduling techniques, static and dynamic systems, optimality of EDF and LST algorithms, off-line and on-line scheduling, clock driven scheduling, cyclic executives, scheduling of aperiodic and static jobs, priority driven scheduling, fixed and dynamic priority algorithms, schedulable utilization, RM and DM algorithms, priority scheduling of aperiodic and sporadic jobs, deferrable and sporadic servers, resource access control, priority inversion, priority inheritance and priority ceiling protocols, real-time communication, operating systems. The Laboratory Classes will be conducted using TI C2000 Platform.

Rathna G N

References: Jane,Liu W S,Real-Time Systems,Pearson Education,New Delhi

E1 213 (JAN) 3:1

Pattern Recognition and Neural Networks

Introduction to pattern recognition, Bayesian decision theory, supervised learning from data, parametric and non parametric estimation of density functions, Bayes and nearest neighbor classifiers, introduction to statistical learning theory, empirical risk minimization, discriminant functions, learning linear discriminant functions, Perceptron, linear least squares regression, LMS algorithm, artificial neural networks for pattern classification and function learning, multilayer feed forward networks, backpropagation, RBF networks, deep neural Networks, support vector machines, kernel based methods, feature selection and dimensionality reduction methods.

Subbayya Sastry P

Pre-requisite: Knowledge of Probability theory References:,Dudo R O, Hart P E & Stork D G, Pattern Classification John Wiley & sons, 2002.,Bishop C M, Neural Network & Pattern Recognition, Oxford University Press(Indian Edition) 2003.

E5 231 (JAN) 2:1

Outdoor Insulation

Electric power transmission, AC & DC, overhead lines, air insulated substations, outdoor insulation functions, Types of line and station insulators up to 1200 kV, wall/equipment bushings, HVDC insulators, Materials used for outdoor insulation; porcelain, glass, synthetic/composite, wood, Types of stresses – electrical, mechanical, thermal, environmental, and extraneous and their implications, Aging mechanisms and failure modes, Deterioration of synthetic insulator due to UV rays and corona, Performance of Insulators in polluted/contaminated conditions and remedial measures, Field experience and standards employed for the evaluation, Maintenance and inspection of insulators in service, Computer simulation for estimation of electrical surface and bulk stress, lab experiments on insulator discs/strings for dry/wet (artificial rain) and polluted conditions, for both ac and dc high voltages.

Subba Reddy Basappa, Udaya Kumar

References: Transmission Line Reference book 345 kV and above, EPRI, Palo Alto, USA, 1982,Ravi S Gorur, Edward Cherney and Jeffrey Burnham, “Outdoor Insulators”, text book, Phoenix, Arizona, USA 1999.,Bradwell A, “Electrical Insulation”, text book, Peter Peregrinus Ltd, London, UK, 1983 Recent Journal/ Conference and CIGRE publications.

E6 221 (JAN) 3:1

Switched Mode Power Conversion

Switched mode power supplies (SMPS): Non-isolated dc-dc converter topologies: continuous conduction mode (CCM) and discontinuous conduction mode (DCM) analysis; non-idealities in the SMPS. Modeling and control of SMPS, duty cycle and current model control, canonical model of the converter under CCM and DCM. Extra element theorem, input filter design. Isolated dc-dc converters: flyback, forward, push-pull, half bridge and full bridge topologies. High frequency output stage in SMPS: voltage doubler and current doubler output rectifiers. Power semiconductor devices for SMPS: static and switching characteristics, power loss evaluation, turn-on and turn-off snubber design. Resonant SMPS: load resonant converters, quasy resonant converters and resonant transition converters.Laboratory excercises on : Opamp circuits for current and voltage sensing in converters, differencial amplifiers for sensing in presence of common mode signals, higher order opamp filters, phase shifters, and pulse width modulators, comparator circuits, efficiency modeling and prediction in dc-dc converters, dymnamic response and compensator design for dc-dc converters.

Vinod John

References: Robert Ericson, Fundamentals of Power Electronics, Chapman & Hall, 2004.,Ramanarayanan V., Switched Mode Power Conversion, 2007 Umanand L, Power Electronics: Essentials and Applications, Wiley India, 2009.,Jayant Baliga B, Power Semiconductor Devices, PWS 1996.

E9 213 (JAN) 3:0

Time-Frequency Analysis

Time-frequency distributions: temporal and spectral representations of signals, instantaneous frequency, Gabor’s analytic signal, the Hilbert and fractional Hilbert transforms, Heisenberg’s uncertainty principle, densities and characteristic functions, global averages and local averages, the short-time Fourier transform (STFT), filterbank interpretation of STFT, the Wigner distribution and its derivatives, Cohen’s class of distributions (kernel method), bilinear time-frequency distributions, Wigner’s theorem, multicomponent signals, instantaneous bandwidth, positive distributions satisfying the marginals, Gabor transform Spaces and bases: Hilbert space, Banach space, orthogonal bases, orthonormal bases, Riesz bases, biorthogonal bases, Frames, shift-invariant spaces, Shannon sampling theorem, B-splines.Wavelets: Wavelet transform, real wavelets, analytic wavelets, dyadic wavelet transform, wavelet bases, multi resolution analysis, two-scale equation, conjugate mirror filters, vanishing moments, regularity, Lipschitz regularity, Fix-Strang conditions, compact support, Shannon, Meyer, Haar and Battle-Lemarié wavelets, Daubechies wavelets, relationship between wavelets and filterbanks, perfect reconstruction filterbanks.

Chandra Sekhar Seelamantula

References: Cohen L, Time Frequency Analysis, Prentice Hall, 1995,Mallat S, A Wavelet Tour of Signal Processing -,The Sparse Way, Elsevier, Third Edition, 2009.

E9 261 (JAN) 3:1

Speech Information Processing

Human speech communication: physiology of speech production, phonetics and phonology. speech perception and illusions. Time- domain features. Time-varying signal analysis: short-time Fourier transform, spectrogram, quasi-stationary analysis: cepstrum, linear-prediction models. Line spectral pair, Mel frequency cepstral coefficients. sinusoidal models. Principles of Speech synthesis, prosody, quality evaluation, pitch and time scale modification. Speech as a sequence of vectors: orthogonal transforms, principal component analysis, vector quantization, Gaussian mixture model and their applications. Dynamic time warping and hidden Markov models. Speaker recognition.

Prasanta Kumar Ghosh, Sriram Ganapathy

Pre-requisites: E9-201 or consent of the instructor.,References: Handbook of Speech Processing, Benesty, Jacob; Sondhi, M. M.; Huang, Yiteng (Eds.), Springer, 2008. Gold B, and Morgan N, Speech and Audio Signal Processing, John Wiley, 2000.,Douglas O'shoughnessy, Speech Communication, IEEE Press 2000. Taylor P, Text-to-Speech Synthesis, Cambridge Univ. Press, 2009. Rabiner L R, and Schafer R W, Theory and applications of digital speech processing, Pearson, 2011.,Quatieri T F, Discrete-time speech signal processing, Prentice-Hall, 2002. Recent literature.

E9 243 (JAN) 3:0

Computer Aided Tomographic Imaging

Introduction to principles of tomography and applications, tomographic imaging. Radon transform and its properties, mathematical framework. Introduction to X-ray tomography, emission computer tomography, magnetic resonance imaging systems. Projection and Fourier slice theorem. Scanning geometries: translate and rotate, translate-rotate, rotate on a circular trajectory for 2-D imaging and helical or spiral scan trajectory for 3-D imaging. Transform domain algorithms: Fourier inversion algorithms, filtered back projection algorithms – reconstruction with non-diffracting sources, parallel projections and fan projections for 2-D and cone beam projections on circular and spiral trajectory for 3-D reconstruction. Computer implementation, iterative reconstruction techniques: algebraic reconstruction techniques, statistical modeling of generation, transmission and detection processes in X-Ray CT, artifacts and noise in CT images. Image reconstruction with incomplete and noisy data, applications of Radon transform in 2-D Signal and Image processing.

Rajgopal K

References: Kak A C, and Slaney M, Principles of Computerized Tomographic Imaging, IEEE Press, 1988.,Herman G T, Image Reconstruction from Projections, Implementation and Applications: Topics in Applied Physics, Vol 32, Springer Verlag, 1979.,Natterer F, The Mathematics of Computerized Tomography, SIAM Classics In Applied Mathematics, Vol. 32, 2001. Natterer F, and Wubbeling F, Mathematical Tools in Image Reconstruction, SIAM, 2001.

E9 282 (JAN) 2:1

Neural Signal Processing

Biophysics and computational techniques for the analysis of action potentials, Local Field Potential (LFP), Electrocortico/encephalogram (ECoG/EEG) and functional Magnetic Resonance Imaging (fMRI). Techniques include stochastic processes, self organized criticality, time-frequency analysis, sparse signal processing, coherence, information theoretic methods, ICA/PCA, forward and inverse modeling, directed tranfer functions, Granger causality, image processing methods and reverse correlation.

Chandra Sekhar Seelamantula, Supratim Ray

References: Kandel, Schwartz and Jessell. Principles of Neural Science, 4th Edition.,Buzsaki G, Rhythms of the brain, Oxford University Press, USA 2006.,Poldrack R A, Mumford J A and Nichols T E, Handbook of functional MRI data analysis, Cambridge University Press, New York, 2009. Mallat S, A Wavelet Tour of Signal Processing - The sparse way, Elsevier, Third Edition, 2009 Thomas M. Cover and Joy A. Thomas, Elements of Information Theory, 2nd Edition, Wiley series in Telecommunications and Signal Processing, 1991.

E9 246 (JAN) 3:1

Advanced Image Processing

Image Features - Harris corner detector, Scale Invariant Feature Transform (SIFT), Speeded Up Robust Features (SURF), edge detection, Hough Transform; Image Enhancement - Noise models, image denoising using linear filters, order statistics based filters and wavelet shrinkage methods, image sharpening, image super-resolution; Image Segmentation - Graph-based techniques, Active Contours, Active Shape Models, Active Appearance Models; Image Compression - Entropy coding, lossless JPEG, perceptually lossless coding, quantization, JPEG, JPEG2000; Image Quality - Natural scene statistics, quality assessment based on structural and statistical approaches, blind quality assessment; Statistical tools - Kalman Filter, Hidden Markov Models; Video Processing - Video standards, motion estimation, compression.

Soma Biswas, Rajiv Soundararajan

Pre-requisites: E9 241: Digital Image Processing,References: David A. Forsyth and Jean Ponce, Computer Vision: A Modern Approach, Pearson Education, 2003,Richard Szeliski, Computer Vision: Algorithms and Applications, Springer, 2010. Simon J.D. Prince, Computer Vision: Models, Learning, and Inference, Cambridge University Press, 2012.

E3 252 (JAN) 3:1

Embedded System Design for Power Application

Digital Signal Controller (A micro-controller with a DSP engine): Architecture and real time programming in Assembly and Embedded C. Introduction to Fixed Point Arithmetic. Field Programmable Gate Array (FPGA): Architecture and programming of digital circuits including Finite State Machines (FSM) in Verilog HDL. Communication-Chip level: AXI, Board level: SPI, I2C, System level: RS 232, CAN, MODBUS RTU on RS 485. Developing a GUI for supervisory control and monitoring. Introduction to different semiconductor memories: RAM, ROM, NVRAM etc. and their applications. Analog sensing: Anti-aliasing filter design, scaling for fixed point computation, online calibration and biasing. Continuous time feedback controller design and its discrete timeimplementation,D/A and A/D converters, effects of sampling, modeling the Pulse Width Modulator (PWM) etc.Co-design: How to optimally implement an embedded task using a programmable processor (DSC) and a re-configurable hardware (FPGA). Embedded design of a typical Power Conversion System including: process control, protection, monitoring, feedback control etc.

Jayachandra Shenoy U, Kaushik Basu

Prerequisite: Under graduate level analog electronics, digital electronics and classical feedback control theory.,Familiarity with micro-processor, digital signal processing, power electronics (E6 201) previous experience in programming will be helpful but not a necessity.,References: Brown s, and Vranesic Z, Fundamentals of Digital logic with Verilog design, Tata McGraw Hill. Mazidi, Mckinlay and Causey, PIC Micro-controllers and Embedded Systems, Pearson. Franklin G F, Powell J D and Naeini, Feedback Control of Dynamic Systems, Pearson. Erickson R W and Maksimovic D, Fundamentals of Power Electronics, Springer. Proakis J G and Manolakis D K, Digital Signal Processing, Pearson.

E6 223 (JAN) 3:0

PWM Converters and Applications

AC/DC and DC/AC power conversion. Overview of applications of voltage source converters, pulse modulation techniques for 1-phase and 3-phase bridges; bus clamping PWM, space vector based PWM, advanced PWM techniques, practical devices in converter. Calculation of switching and conduction losses. Compensation for dead time and DC voltage regulation; dynamic model of a PWM converter, multilevel converters; constant V/F induction motor drives; estimation of current ripple and torque ripple in inverter fed drives. Line-side converters with power factor compensation.

Narayanan G

References: Mohan, Undeland and Robbins; Power Electronics; Converters, Applications and Design, John Wiley and Sons, 1989.,Erickson R W, Fundamentals of Power Electronics, Chapman and Hall, 1997.,Vithyathil J, Power Electronics: Principles and Applications; McGraw Hill, 1995. Current Literature.

E1 242 (JAN) 3:0

Nonlinear Systems And Control

Pavankumar Tallapragada

EP 299 (JAN) 0:28

Project

This includes the analysis, design of hardware/software, construction of an apparatus/Instrument and testing and evaluation of its performance. Usually, the project work is based on a scientific/engineering problem of current interest. And every student has to complete the work in the specified period and should submit the Project Report for final evaluation.

Satish L

E5 232 (MAY) 2:1

Advances in Electric Power Transmission

Dept of Electronic Systems Engineering

E2 232 (AUG) 2:1

TCP/IP Networking

IP addressing, IP header; subnetting and supernetting, CIDR, routing table, Ethernet, ARP; Serial links, PPP, ICMP, UDP, TCP: header, connection establishment, ISN, half close, delayed acks, header flags, TCP state transitions, sliding window, Slow Start, Congestion Avoidance, Fast Retransmit, Fast Recovery; DNS; multicasting, IGMP; IEEE 802.11 wireless LANs; Bridges, L2 switches, Spanning Tree algorithm, VLANs; Mobile IP; Private IP; NAT; DHCP; http; routing protocols:
RIP, OSPF, BGP; IPv6

Prabhakar T V, Dagale Haresh Ramji, Joy Kuri

W. Richard Stevens,TCP/IP Illustrated,Vol I: The Protocols,Pearson Education Asia,2000

E3 235 (AUG) 2:1

Design for Analog Circuits

Introduction to Integrated Circuit Technology, Op-Amps, Single-Stage and Two-Stage Amplifiers, Wideband Amplifiers and Comparators, Instrumentation Amplifiers, Filters, MOSFETs, Current Mirrors
and Active Loads, Frequency Response and Feedback techniques for Integrated Circuits, Noise, CMRR of an Op-Amp and Op-Amp Circuits, Analog-to-Digital Converter (ADC) and Digital-to-Analog Converter (DAC) using Op-Amps, Understanding the Datasheet of Op-Amps, Practical Application of
Op-Amps, Designing Analog Circuits.

Hardik J Pandya

Gray, Hurst, Lewis, and Meyer, Analysis and Design of Analog Integrated Circuits, John Wiley & Sons, 5th edition, 2009,Horowitz and Hill, The Art of Electronics, Cambridge Univ. Press, 1999,Behzad Razavi, Design of Analog CMOS Integrated Circuits, McGraw-Hill, 2001

E3 262 (AUG) 2:1

Electronic Systems Packaging

Electronic systems and needs, physical integration of circuits, packages, boards and complete electronic systems; system applications like computer, automobile, medical and consumer electronics with case studies and packaging levels. Electrical design considerations - power distribution, signal integrity, RF package design and Power-delivery in systems. CAD for Printed Wiring Boards (PWBs) and Design for Manufacturability (DFM). PWB Technologies, Single-chip (SCM) and Multi-chip modules (MCM), flex circuits. Recent trends in manufacturing like microvias, sequential build-up circuits and high-density interconnect structures. Materials and processes in electronics packaging, joining methods in electronics; lead-free solders. Surface Mount Technology – design, fabrication and assembly, embedded passive components; thermal management of PWBs, thermo-mechanical reliability, design for reliability, electrical test and green packaging issues, Assignments in PCB CAD; Hands-on lab sessions for board manufacturing and assembly.

Mahesh G V

Rao R. Tummala, Fundamentals of Microsystems Packaging, McGraw Hill, NY, 2001,Rao R Tummala & Madhavan Swaminathan, Introduction to System-on-Package, McGraw Hill, 2008,R S Khandpur, Printed Circuit Boards, McGraw Hill, 2006

E3 282 (AUG) 3:0

Basics of Semiconductor Devices and Technology

Introduction to semiconductor device physics: Review of quantum mechanics, electrons in periodic lattices, E-k diagrams, quasiparticles (electrons, holes and phonons) in semiconductors. Carrier statics and dynamics, carrier transport under low electric and magnetic fields: Mobility and diffusivity; Carrier statistics; Continuity equation, Poisson's equation and their solution. High field effects: Velocity saturation, hot carriers and avalanche breakdown. Semiconductor Junctions: Schottky, p-n junction and hetero-junctions and related physics. Ideal and nonideal MOS capacitor, band diagrams and CVs; Effects of oxide charges, defects and interface states; Characterization of MOS capacitors: HF and LF CVs. Physics of transistors

Mayank Shrivastava

S. M. Sze,Physics of Semiconductor Devices,John Wiley,Donald Neamen,Semiconductor Physics and Devices

E2 243 (AUG) 2:1

Mathematics for Electrical Engineers

Analysis: The Real Number System, Euclidean Spaces, Metric Spaces, Closed and open sets, Numerical sequences and series, Limits, Continuity. Probability Theory: The axioms of probability theory, Independence and conditional probability, Random variables and their distribution, Expectation, Conditional distribution, Convergence of sequences of random variables, Laws of large numbers and Central limit theorem. Linear Algebra: Vector Spaces, Subspaces, Linear independence, Basis and dimension, Orthogonality; Matrices, Determinants, Eigenvalues and Eigenvectors, Positive definite matrices, Singular Value Decomposition.

Chandramani Kishore Singh

Rudin, W., Principles of Mathematical Analysis, McGraw-Hill, 1985,Strang G, Linear Algebra and Applications, ThomsonBrooks/Cole, 4th Edition, 2006,D. P. Bertsekas, J. N. Tsitsiklis, Introduction to Probability, Athena Scientific Press, 2nd Edition, 2008

E3 245 (AUG) 2:1

Processor System Design

Introduction: Basic Processor Architecture, Instruction Set Design, Datapath and Controller, Timing, Pipelining. CISC Processor Design: Architecture, Design. RISC Processor Design: single cycle implementation, multi cycle implementation, pipelined implementation, exception and hazards handling, RISC-V. Memory Hierarchy: Cache, Paging, TLB. Bus: Bus Topologies, AXI, PCIe, Bus Bridges, BFM, Network-on-Chip. Superscalar Processors Design: Superscalar organization, superscalar pipeline overview, VLSI implementation of dynamic pipelines, register renaming, reservation station, reordering buffers, branch predictor, and dynamic instruction scheduler etc.

Kuruvilla Varghese

Computer Organization and Design: The Hardware/Software Interface, The Morgan Kaufmann, By David A. Patterson and John L. Hennessy,Computer Architecture: A Quantitative Approach, The Morgan Kaufmann By John L. Hennessy and David A. Patterson,Modern Processor Design: Fundamentals of Superscalar Processors, McGraw-Hill By John P. Shen,Current Literature,Prerequisite: E0 284, E3 231

E0 284 (AUG) 2:1

Digital VLSI Circuits

Introduction to MOS transistor theory, Circuit characterization & simulation, theory of logical effort, interconnect design and analysis combinational circuit design, sequential circuit design. Design methodology & tools, testing & verification, datapath subsystems, array subsystems, power and clock
distribution, introduction to packaging.

Chetan Singh Thakur

N. Weste and D. Harris, CMOS VLSI Design. A Circuits and Systems Perspective, Addison Wesley, 2005~J. M. Rabaey, A. Chandrakasan, and B. Nikolic, Digital Integrated Circuits~Current literature

E0 284 (AUG) 2:1

Digital VLSI

Digital VLSI design, Digital IC design

Chetan Singh Thakur

E3 258 (JAN) 2:1

Design for Internet of Things

Embedded Systems: Rise of embedded systems and their transition to intelligent systems and to Internet of Things - RFIDs, NFC, Web of Things - Network of interconnected and collaborating objects, Embedded systems architecture: Key hardware and software elements, typical embedded processors like ATOM. Low power and very low power embedded systems, peripherals and sensors in embedded systems, peripheral interfacing - SPI and I2C, Hardware and software protocol stacks - MAC, Routing and application layers, performance considerations. Embedded Systems Design: Partitioning to hardware and software; principles of co-design; performance of these systems - estimation of speed, throughput, power and energy consumption; hardware design elements - design, validation, and testing tools; software platforms – OS and applications, code optimization, validation and robust code generation; system integration, debugging and test methodology; tools for coding, debugging, optimization, and documentation; measurement of system performance, Linux distributions for embedded systems using tools from Yocto project; Creating virtual prototypes - hardware software emulation. Applications: Healthcare and home automation examples.

Prabhakar T V

Barry,P.,and Crowley,P.,Modern Embedded Computing

E3 275 (JAN) 3:0

Physics and Design of Transistors

1. The Ideal MOS Capacitor: The Silicon/Silicon Dioxide System, Band Bending in the MOS Capacitor, Solution of Poisson's Equation for the MOS Capacitor, Depletion Approximation, Threshold Voltage, Capacitance-Voltage (CV) Plot of the Ideal MOS Capacitor, Small-signal Capacitance and Equivalent Circuit, Low-frequency Capacitance-Voltage (LFCV) Characteristics, High-frequency Capacitance-Voltage (HFCV) Characteristics and Deep Depletion.

2. The Non-Ideal MOS Capacitor: Work Function Difference, Oxide and Interface Charges, Nature of Defects in the Oxide and at the Si/SiO2 Interface, Effect of Oxide Charges, Effect of Interface States, Stretchout in the HFCV Characteristic, Interface State Capacitance and Equivalent Circuit, LFCV Characteristic with Interface States, Effect of Border States, Series Resistance, Non-Uniform Doping, Lateral Non-Uniformities, Polysilicon Depletion Effects, Failure of Maxwell-Boltzmann Statistics, Quantum Effects and Tunnelling through the Insulator

3. The MOS Capacitor as a Diagnostic Device: Determination of Basic MOS Parameters - Oxide Thickness, Substrate Doping, The Ideal HFCV Curve, Flat-band and Mid-gap Capacitances and Voltages, Threshold Voltage and Work Function Difference. Oxide Charge and Interface States, Determination of Interface State Density, The HF-LF CV Technique, Conductance Method, Continuum of States, Deep Level Transient Spectroscopy (DLTS), Determination of Oxide Charge and Effects of Quantization on the Extraction of Parameters

4. The Long Channel MOSFET: Simplified I-V models of the MOSFET. Various MOSFET models and aspects like body effect, threshold voltage model, sub-threshold swing model, sub-threshold conduction, OFF and ON state behaviour using band diagrams, LF and HF CV characteristics.

5. The Short Channel MOSFET: Threshold voltage change with channel length scaling, Drain Induced Barrier Lowering, Channel Length Modulation, Velocity Saturation, Mobility Degradation, Punch-through, HC effects, parasitic bipolar effect, Gate Induced Drain Leakage, Effect of thin Gox, Transistor Scaling and scaling Implications.

6. Double Gate MOSFET and FinFETs: FDSOI and PDSOI. Limitation of FDSOI technology. Why FinFETs? FinFET advantages over FDSOI, FinFET Design, SOI vs. Bulk FinFETs, band diagram, scaling and variability issues/advantages, effect of Fin Width, effect of S/D resistance, mobility, quantum confinement effects and bulk conduction. P and N conduction, impact of crystal plane. High-k & Metal Gate for FinFETs, Process flow and complexities, doping thin films, raised S/D, epitaxial S/D, stress and other mobility boosters. FinFET based circuit design advantages (Logic, SRAM, Analog/RF), limitations and other challenges. FinFET layout design rules. HV/ESD device and SoC design challenges in FinFETs. Basics of Nanowire FETs.

Mayank Shrivastava

Lecture Notes,Physics of Semiconductor Devices : S.M. Sze

E3 231 (JAN) 2:1

Digital Systems Design with FPGAs

Introduction to Digital design; Hierarchical design, controller (FSM), case study, FSM issues, timing issues, pipelining, resource sharing, metastability, synchronization, MTBF Analysis, setup/hold time of various types of flip-flops, synchronization between multiple clock domains, reset recovery, proper resets. VHDL: different models, simulation cycles, process, concurrent and sequential statements, loops, delay models, library, packages, functions, procedures, coding for synthesis, test bench.

FPGA: logic block and routing architecture, design methodology, special resources, Spartan-6 architecture, programming FPGA, constraints, STA, timing closure, case study.

Kuruvilla Varghese

Digital Design: Principles and Practices By J. F. Wakerly, Pearson,VHDL for Programmable Logic, By Kevin Skahill, Pearson,FPGA Data sheets, Application Notes,Current literature

E3 257 (JAN) 2:1

Embedded System Design - I

Development toolchain (Compiler, Linker and Debugger), ARM Cortex processor architecture, Memory subsystem, caching, interfacing and programming peripherals, GPIO, UART, I2C, SPI, interrupts and NVIC architecture, interrupt driven standalone system

Dagale Haresh Ramji

Definitive Guide to Cortex M3 Architecture,Joseph Yiu,Practical Microcontroller Engineering with ARM Technology,Ying Bai,Linkers & Loaders

E3 271 (JAN) 3:0

Reliability of Nanoscale Circuits and Systems

Carrier transport and carrier energy fundamentals, avalanche multiplication and breakdown, hot carrier induced (HCI) degradation mechanism, NBTI/PBTI, TDDB, GOI and Electromigration, ESD and latch-up phenomena, Test models and methods, ESD protection devices and device physics, Advance ESD protection devices, high current effects and filaments, Negative differential resistance, Physics of ESD failure, ESD protection methodology, ESD protection circuits, ESD protection for Analog/RF and mixed signal modules, General rules for ESD design, layout considerations for ESD and latch-up protection, understanding parasitics, ESD circuit simulation basics and requirements, ESD TCAD simulation methodology, System on Chip overview and system ESD aspects, case studies related to product failures and solutions use

Mayank Shrivastava

Review Papers on NBTI/PBTI, HCI Degradation, TDDB, Electromigration,ESD in Silicon Integrated Circuits by Ajith Amerasekera and Charvaka Duvvury, Wiley publication,Basic ESD and I/O Design by Sanjay Dabral and Timothy J. Maloney, Wiley publication

E3 258 (JAN) 2:1

Design for Internet of Things

Embedded Systems: Rise of embedded systems and their transition to intelligent systems and to Internet of Things - RFIDs, NFC, Web of Things - Network of interconnected and collaborating objects, Embedded systems architecture: Key hardware and software elements, typical embedded processors like ATOM. Low power and very low power embedded systems, peripherals and sensors in embedded systems, peripheral interfacing - SPI and I2C, Hardware and software protocol stacks - MAC, Routing and application layers, performance considerations. Embedded Systems Design: Partitioning to hardware and software; principles of co-design; performance of these systems - estimation of speed, throughput, power and energy consumption; hardware design elements -

design, validation, and testing tools; software platforms – OS and applications, code optimization, validation and robust code generation; system integration, debugging and test methodology; tools for coding, debugging, optimization, and documentation; measurement of system performance, Linux distributions for embedded systems using tools from Yocto project; Creating virtual prototypes - hardware software emulation. Applications: Healthcare and home automation examples.

Prabhakar T V, Chandramani Kishore Singh

Barry, P., and Crowley, P., Modern Embedded Computing, Morgan Kaufmann, 2012,Wolf, M., Computers as components Third edition, Morgan Kaufmann, 2012,Other online references to be provided during the course

E3 272 (JAN) 3:0

Advanced ESD devices, Circuits and Design Methods

History of key inventions in the field of ESD and latch-up protection, Review on various ESD testers and ESD test models, problems associated with ESD testers and progress on ESD tester development. High current injection, High field effects, Negative differential resistance and Current filaments, Drain extended MOS devices and associated week ESD robustness. ESD behavior of FinFET devices, SiGe-FETs and other quantum well devices, Impact of stress & strain on ESD behavior, ESD devices in advanced CMOS and BiCMOS technology, Impact of technology scaling on ESD behavior, Special analog and RF ESD protection devices and circuits. Impact of ESD stress on CNTs, Graphene and other 2D material based Nanoelectronic devices. ESD Device modeling for circuit simulations, State-of-the-art on CDM ESD protection, CDM tester models, modeling CDM behavior and CDM simulations, ESD verification flow and methodology, Towards full chip ESD simulation, Transient latch-up, System level ESD, System efficient ESD design (SEED), Case studies.

Mayank Shrivastava

ESD Protection Device and Design for Advanced CMOS Technologies by Oleg Semenov, Hossein Sarbishaei and Manoj Sachdev, Elsevier,ESD RF Technology and Circuits by Steven H. Voldman, Wiley,Nanoelectronics – Nanowires, Molecular Electronics and Nanodevices by Krzysztof Iniewski, McGraw Hill, 201

E3 290 (JAN) 2:1

Microfabrication Technology and Process for Biology and Medicine

Introduction to microfabricated devices for biology and medicine (devices for flow cytometry/sorting, microchips using dielectrophoresis, force measurement with cantilevers, microengineered devices for medical therapeutics, blood pressure sensors, devices for drug delivery, devices for minimally invasive surgery), Microfabrication technology: Introduction to the clean room, Contaminants, Wafer cleaning processes (DI water, RCA, metallic impurities, etc.), Substrate materials, Techniques of metallization: PVD [(Sputtering – DC, RF, and Magnetron), thermal evaporation, e-beam evaporation, PLD], Types of masks, Hard and soft Lithography, Types of etching, Design of process flow for device fabrication for application in biology and medicine, Basics of tissue culture methods: Types of cell growth, Work area and equipment (Laminar flow hoods, CO_2 incubators, Microscopes, Preservation, Vessels, Storage), Maintaining cells (harvesting, media and growth requirements), Safety considerations, Cell counting, Device fabrication and inspection in the clean room.

Hardik J Pandya

J.D. Plummer, M.D. Deal, P.G. Griffin, Silicon VLSI Technology, Pearson Education, 2001,S.A. Campbell, The Science and Engineering of Microelectronic Fabrication, Oxford University Press, 2001,S.M. Sze (Ed), VLSI Technology, 2nd Edition, McGraw Hill, 198

E9 207 (JAN) 3:0

Basics of Signal Processing

Introduction to probability and random processes: basic definitions, discrete, continuous and mixed random variables, probability density function, cumulative density function, various notions of stationarity, ergodicity, filtering noise through linear systems, Signal spaces and signal geometry, Topics in sampling: Shannon sampling theorem for bandlimited and random signals, basic ideas on compressive sampling, Sampling rate conversion: decimation, expansion and rational fractional rate conversion, filter banks and applications. Introduction to transform methods: Fourier transforms and convergence issues, wavelets and algorithms for fast decomposition.

Shayan Garani Srinivasa

Moon and Stirling,Mathematical Methods and Algorithms for Signal Processing,Prentice Hall 2000,P. P. Vaidyanathan,Multirate systems and filterbanks

E1 243 (JAN) 2:1

Digital Controller Design

Modeling of Systems: input/output relations, linearization, transfer function and state space representations, circuit averaging, bond graph and space vector modeling; Control system essentialsrepresentation in digital domain, z-transform, digital filters, s-z mapping, sampling issues, continuous to discrete domain conversions; Controller design-Bode method, root locus method, PID controller, State space methods, full state feedback, pole placement, estimator design, prediction, current and reduced order estimators, introduction to optimal and robust controller design.

Umanand L

Franklin, G.F., Powell, J.D., Workman, M.L., Digital Control of Dynamic Systems, 2nd Ed., AddisonWesley, MA, USA, 1990,Friedland, B., Control System Design-An Introduction to State Space Methods, McGraw Hill, 1987,Lewis, F.L., Applied Optimal Control and Estimation, Prentice Hall, USA, 1992

E6 212 (JAN) 3:0

Design and Control of Power Converters and Drives

Basics of phase controlled converters, Choppers, Front end Ac to DC converter, DC motor speed control, inverters, six step operation, sinusoidal PWM control, current hysteresis PWM and space vector PWM control of three phase inverters. Generation of the three phase PWM signals from sampled reference phase amplitudes and PWM control in overmodulation region, Speed control of induction motor; V/f operation, dynamic equivalent circuit model of induction motor and vector control
of induction motor. Current source inverter, Multilevel inverters and its control.

Gopakumar K

Leonhard W., Control of Electrical Drives, Springer-Verlag, 1985,Mohan, Undeland and Robbins, Power Electronics: Converters, Application and Design, John Wiley and Sons, 1989,Krishnan, R., Electric Motor drives: Modelling, Analysis and Control, Prentice Hall, March 2001 Gopakumar K., Lecture notes

E9 251 (JAN) 3:0

Signal Processing for Data Recording Channels

Introduction: Review of basic principles behind the physics of magnetic recording, super paramagnetic limits, technological trends in magnetic storage/optical systems, recording schemes in magnetic and optical devices. Signal Modeling: Communication theoretic framework of read/write channels. Models for analog read back signal with inter-symbol interference, noise and distortion sources, notion of channel and user bit densities towards SNR definition. Signal Processing Methods: Equalization and timing recovery, PLLs, ML based timing recovery methods, Detection techniques based on the BCJR algorithm and its low complexity variations, turbo-equalization methods. Coding Techniques: Introduction to constrained modulation codes, review of algebraic and graphical coding techniques, interleaving mechanisms and analysis of the code performance. Implementation: Hardware related aspects for realizing signal processing algorithms on a system-on-chip (SoC).

Shayan Garani Srinivasa

Bergmans,J.W.M.,Digital Baseband Transmission and Recording,Kluwer Academic Press,1996

E6 222 (JAN) 2:1

Design of Photovoltaic Systems

Introduction to photovoltaic energy conversion, Solar radiation and measurement, Solar cell and their characterization, Influence of insolation and temperature, Maximum power point tracking, Electrical storage with Batteries, controllers, DC power conditioning, AC power conditioners for grid connection,Solar power drives, Applications for pumping/refrigeration, Economic analysis of PV system, Energy analysis of PV system

Umanand L

Chenming, H. and White, R.M., Solar Cells from B to Advanced Systems, McGraw Hill Book Co.,Ruschenbach, HS, Solar Cell Array Design Hand Varmostrand, Reinhold, NY, 1980,Proceedings of IEEE Photovoltaics Specialists Conference, Solar Energy Journa

E3 375 (JAN) 3:0

Basics of Nanoelectronics

Introduction to CMOS Scaling, The nanoscale MOSFET and design, Finfets, NanoWire FETs and Tunnel FETs, fundamental limit to device scaling and device engineering for CMOS scaling. Carbon nanotube, graphene and other 2D semiconductors and related nanoelectronics, band structure & transport, devices, applications.

Mayank Shrivastava

Fundamentals of Nano transistors By Mark Lundstrom,Current Literature,Current Literature

E3 274 (JAN) 3:0

Design of Power Semiconductor Devices

Power device applications: Power electronic applications, High voltage and high-power circuits, RF power circuits and applications, On-chip circuits and power management system, high switching speed requirements for power system scaling. Semiconductor Physics under extreme conditions: Basics of semiconductor device physics, p-n junction, carrier transport under extreme conditions, avalanche breakdown, and thermal transport. Power Diodes: Various types of power diodes: Si diodes, Schottky diodes and P-i-N diodes; Physics of power diodes, power diode design essentials, breakdown voltage and ON-resistance trade-off, high current and ultra fast transient behavior. Si High Power MOS devices, design and Technology: VMOS, VDMOS, UMOS, DMOS, LDMOS, DeMOS and Dual trench MOS; Process flow, discrete and On-chip device manufacturing technology; High power MOS design essentials, breakdown voltage and on-resistance trade-off, parasitic capacitance and resistances, DC, RF and switching characteristics; quasi saturation behavior, high current effects, Negative differential resistance (NDR), self heating, filament formation and safe operating area (SOA). GaN and SiC Power MOS devices: Advantage of high bandgap materials, High bandgap material physics, various GaN/SiC devices, device physics and design essentials, GaN/SiC device manufacturing technology; breakdown voltage and on-resistance trade-off, parasitic capacitance and resistances, DC, RF and switching characteristics; quasi saturation behavior, self heating effects and safe operating area (SOA); state-of-the-art GaN/SiC devices and ongoing research. IGBTs and SCR: IGBTs and SCR device physics and device design essentials, breakdown voltage and on-resistance trade-off, self heating effects and filament formation.

Mayank Shrivastava

Semiconductor power devices: Physics of operation and fabrication technology, Sorab Khushro Ghandhi, Wiley, 1977,Advanced Power MOSFET Concepts, B. Jayant Baliga, 2010,High Voltage Devices and Circuits in Standard CMOS Technologies, Hussein Ballan, Michel Declercq

E3 225 (JAN) 3:0

Compact Modeling of Devices

Band theory of solids, carrier transport mechanism, P-N junction diode, MOS Capacitor Theory, C-V characteristics, MOSFET operation, Types of compact models, Input Voltage Equation, Charge Linearization, Charge Modeling, Concept of Core Model, Quasi-static and Non-quasi-static Model, Introduction to Verilog-A, Basic theory of circuit simulation, Brief overview of EKV and PSP

Santanu Mahapatra

Tsividis,Y.,Operation and Modelling of the MOS Transistor,Oxford University Press,2012

E2 231 (JAN) 3:0

Topics in Statistical Methods

Random Walks on Graphs – main parameters, the eigenvalue connection, the electrical connection, mixing rate, sampling by random walks, Markov random fields, Gibbs sampling, Markov chain Monte Carlo, Metropolis Hastings, Simulated annealing, Belief propagation, Bethe free energy, Kikuchi approximation, generalized belief propagation, convergence of belief propagation, Cavity method, Correlation decay, Learning Graphical models.

Chandramani Kishore Singh

M. Jordan (ed.),Learning in Graphical Models,MIT Press,1998,M. Mézard and A. Montanari

EP 299 (JAN) 0:22

Project

This includes the analysis, design of hardware/software, construction of an apparatus/Instrument and testing and evaluation of its performance. Usually, the project work is based on a scientific/engineering problem of current interest. And every student has to complete the work in the specified period and should submit the Project Report for final evaluation.

Satish L

Division of Mechanical Sciences

Preface

The Division of Mechanical Sciences consists of the departments of Aerospace Engineering, Atmospheric and Oceanic Sciences, Civil Engineering Chemical Engineering, Divecha Centre for Climate Change, Earth Sciences, Mechanical Engineering, Materials Engineering, Product Design and Manufacturing and Sustainable Technology. It also administers an Institute facility, 'Advanced Facility for Microscopy and Microanalysis'. The courses offered in the different departments of the Division have been reorganized after review and revision, and have been grouped department wise. These are identified by the following code.

AE	Aerospace Engineering
AS	Atmospheric and Oceanic Sciences
CE	Civil Engineering
CH	Chemical Engineering
DC	Divecha Centre of Climate Change
ER	Earth Sciences
ME	Mechanical Engineering
MT	Materials Engineering
PD	Product Design and Manufacturing
ST	Sustainable Technologies

The first two digits of the course number have the departmental code as the prefix. All the Departments/Centres (except the Space Technology Cell) of the Division provide facilities for research work leading to the degrees of M Tech (Research) and Ph D. There are specific requirements for completing a Research Training Programme for students registered for research at the Institute. For individual requirements, students are advised to consult the Departmental Curriculum Committee. M Tech Degree Programmes are offered in all the above departments except in the Centre for Product Design and Manufacturing which offers M.Des. Department of Civil Engg and CiSTUP jointly offer an M Tech Programme in Transportation Engineering. Most of the courses are offered by the faculty members of the Division, but in certain areas, instruction by specialists in the field and experts from industries are also arranged.

Prof. Vikram Jayaram
Chairman
Division of Mechanical Sciences

Dept of Aerospace Engineering

Details of the Aerospace Engineering

M Tech Programme (2018-19 Batch) Duration: 2 years 64 Credits

Semester I	Semester 2	Semester 3	Semester 4
Flight and Space Mechanics	**Math requirement** (3 credits) Either 2^{nd} or 3^{rd} semester		**Aerospace Seminar**
Fluid Dynamics	**Elective 1**	**Elective 5**	
Mechanics and Thermodynamics of Propulsion	**Elective 2**	**Elective 6**	
Flight Vehicle Structures	**Elective 3**	**Elective 7** Either 3^{rd} or 4^{th} semester	
Navigation, Guidance and Control	**Elective 4**	**Elective 8**	
Experimental Techniques in Aerospace Engineering		**MTech Dissertation** (20 credits) Distributed over 3^{rd} and 4^{th} semesters	
16 credits	**48 credits (Minimum 12 credits per semester)**		

SOI Details of the Aerospace Engineering For the Batch of 2017- 2018
M Tech Programme Duration: 2 years 64 Credits
Hard Core: 24 Credits
AE 203 3:0 Fluid Dynamics
AE 220 3:0 Flight and Space Mechanics
AE 221 3:0 Flight Vehicle Structures
AE 245 3:0 Mechanics and Thermodynamics of Propulsion
AE 259 3:0 Navigation, Guidance and Control
AE 271 1:2 Flight Vehicle Design

AE 276 1:2 Experimental Techniques
AE 211 3:0 Mathematics for Aerospace Engineers

AE 299 : 0:19 Dissertation Project

Electives: A balance of 21 credits is required to make up a minimum of 64 credits. A minimum of two courses in Aerodynamics/Guidance and Control/ Propulsion/ Structure needs to be taken from the departmental courses listed below. This leaves approximately 12 credits to be taken from electives within/ outside the department.

AE 228 (AUG) 2:1

Computation of Viscous Flows

Review of schemes for Euler equations, structured and unstructured mesh calculations, reconstruction procedure, convergence acceleration devices, schemes for viscous flow discretization, positivity, turbulence model implementation for unstructured mesh calculations, computation of incompressible flows. Introduction to LES and DNS.

Balakrishnan N(CFD)

Prerequisite AE 227

AE 351 (AUG) 3:0

Research Techniques in Non-Destructive Evaluation

Quantitative non destructive evaluation involved probabilistic methods of quality control and life assessment. Signal analysis and image processing in NDE, ultrasonic, thermographic and tomographic methods for evaluation of composites.

Ramachandra Bhat M

Prerequisite AE 258 or equivalent and consent of instructor~References American Society of Metal (ASM) Hand Book, Volume 17.Thompson, D.O., and Chimenti, D.E. Eds, Review of progress in quantitative Non Destructive Evaluation. Annual Conference proceedings.

AE 261 (AUG) 3:0

Structural Vibration Control

Introduction to vibration control, passive and active vibration control. Concept of vibration isolation, dynamic vibration absorber, visco-elastic polymers as constrained and unconstrained configuration in passive vibration control. Constitutive modeling of structures with PZTs/PVDF materials, electro restrictive, magneto restrictive and shape memory alloys. Application of PZT patches, PVDF films, electro restrictive, magneto restrictive materials and shape memory alloys (SMA) in structural vibration control.

Siddanagouda Kandagal

References Nashif, D.N., Jones, D.I.G., and Henderson, J.P., Vibration damping, John Wiley, New York, 1985. Srinivasan, A.V., and McFarland, D.M., Smart Structures: Analysis and Design, Cambridge University Press, Cambridge, 2001. Inman, D.J., Vibration with Control, John Wiley, New York, 2006.

AE 245 (AUG) 3:0

Advanced Combustion

Introduction: review of chemical equilibrium, heat of combustion, adiabatic flame temperature, kinetics. Review of Reynolds transport theorem and conservation equations. Non-premixed flames: mixture fraction, coupling functions. Burke Schumann flame and droplet combustion. Premixed flames: Thermodynamic considerations – Rankine Hugoniot relations: deflagration and detonation, flame speed and thickness phenomenology. Adiabatic flame speed and flame speed with heat loss. Flame stretch, flame speed with stretch, experimental techniques to determine laminar flame speed.Chemical structure of a premixed flame. Introduction to Turbulent Combustion: RANS equations, Favre averaging, length scales, energy spectra, mixing, intermittency. Turbulent Premixed Flames: Regime Diagrams, Turbulent flame speed. Turbulent Non-Premixed Flames: Mixing, scalar dissipation rates, extinction. Introduction to Combustion Instabilities

Santosh Hemchandra, Swetaprovo Chaudhuri

Prerequisites AE 203 or AE 241 or AE 242 or AE 243, or equivalent; Instructor consent.,References Combustion Physics by C. K. Law, Cambridge 2006. Combustion Theory by F. A. Williams, Westview Press 1994. Turbulent Combustion by N.

Peters, Cambridge 2000. Unsteady Combustor Physics by T. Lieuwen, Cambridge 2012. Turbulent Flows by S. B. Pope, Cambridge, 2000. Recent literature.

AE 203 (AUG) 3:0

Mechanics and Thermodynamics of Propulsion

Classical thermodynamics, conservation equations for systems and control volumes, one dimensional flow of a compressible perfect gas – isentropic and non-isentropic flows. Propulsion system performance, the gas generator Brayton cycle, zero dimensional analysis of ideal ramjet, turbojet and turbofan cycles, non-ideality and isentropic efficiencies. Performance analysis of inlets and nozzles, gas turbine combustors, compressors and turbines and discussion of factors limiting performance. Chemical rockets - thrust equation, specific impulse, distinction between solid and liquid rockets, maximum height gained analysis, multi-staging, characteristics of propellants.

Santosh Hemchandra

References Philip G. Hill and Carl R. Peterson. "Mechanics and thermodynamics of propulsion." Reading, MA, Addison-Wesley Publishing Co., 1992. Nicholas Cumpsty and Andrew Heyes, Jet propulsion. Cambridge University Press, 2015. Jack D. Mattingly, Elements of gas turbine propulsion. McGraw-Hill, 1996.

AE 201 (AUG) 3:0

Flight and Space Mechanics

Basics of flight. Airflow in standard atmosphere. Airplane aerodynamics: Airfoils and finite lifting surfaces, thrust, power, level flight gliding, take-off, landing and basic manoeuvres. Airplane performance, stability and control. Mechanics of launch vehicles and satellites.

Ramesh O N

Reference Anderson, J.D. Jr., Introduction to Flight, Fifth Edition, McGraw Hill Higher Education 2007.

AE 202 (AUG) 3:0

Fluid Dynamics

Properties of fluids, kinematics of fluid motion, conservation laws of mass, momentum and energy, potential flows, inviscid flows, vortex dynamics, dimensional analysis, principles of aerodynamics, introduction to laminar viscous flows.

Joseph Mathew

References Kundu, P.K., Cohen, I.M. and Dowling, D.R., Fluid Mechanics, Academic Press, 2016. Fay, J.A., Introduction to Fluid Mechanics, Prentice Hall of India, 1996. Gupta, V. and Gupta, S.K., Fluid Mechanics and its Applications, Wiley Eastern, 1984. Kuethe, A.M. and Chou, S.H., Foundations of Aerodynamics, Wiley, 1972.

AE 204 (AUG) 3:0

Flight Vehicle Structures

Introduction to aircraft structures and materials; introduction to elasticity, torsion, bending and flexural shear, flexural shear flow in thin-walled sections; elastic buckling; failure theories; variational principles and energy methods; loads on aircraft.

Suhasini Gururaja

References Sun, C.T., Mechanics of Aircraft Structures, John Wiley and Sons, New York, 2006. Megson, T.H.G., Aircraft Structures for Engineering Students, Butterworth-Heinemann, Oxford, 2013. Lecture notes.

AE 231 (AUG) 3:0

Aerodynamic Testing Facilities and Measurements

Aerodynamic testing in various speed regimes, requirements of aerodynamic testing, design aspects of low speed wind tunnels, flow visualization methods, measurement methods for flow variables. Wind tunnel balances, elements of computer-based instrumentation, measurements and analyses methods. Elements of high speed wind tunnel testing: design aspects to supersonic and hypersonic wind-tunnels, other high speed facilities like shock tube shock tunnels, free piston tunnels, ballistic ranges and low density tunnels, special aspects of instrumentation for high speed flows.

Gopalan Jagadeesh, Sourabh Suhas Diwan, Srisha Rao M V

Prerequisite AE 202 or equivalent,References William H Roe Jr., and Alan Pope, Low Speed Wind Tunnel Testing Wiley and Sons, 1984Pankhrust, R.C., and Holder, D.W., Wind-Tunnel technique, Sir Isaac Sons Ltd., London, 1968. Lukasiewicz, J., Experimental methods of Hypersonic, Marcel Dekker in New York, 1973. Alan Pope and Kenneth L Going, High-Speed Wind Tunnel Testing, Wiley and Sons, 1965.

AE 244 (AUG) 3:0

Introduction to Acoustics

Conservation equations, wave equation, acoustic energy, intensity and source power, spherical waves, frequency content of rounds, levels and the decibel Fourier series and long duration rounds. Reflection, transmission and excitation of plane waves, specific acoustic impedance, multilayer transmission and reflection, radiation from vibrating bodies. Monopoles and Green’s functions. Reciprocity in acoustics.

Sheshadri T S

Reference Allan d’Pierce, Acoustics McGraw Hill Book Company, 1981.

AE 296 (AUG) 0:1

Experimental Techniques in Aerospace Engineering

Experimental techniques in aerospace engineering is a 0:1 credit course that will include demonstrations of experiments in the major sub-disciplines of aerospace engineering. The intent of this course is to give an overview of the experimental facilities and techniques that are commonly used in research in aerospace. This course will have a pass/fail (P/F) grade based on evaluation at the end of the course.

Ramachandra Bhat M, Siddanagouda Kandagal

AE 254 (AUG) 3:0

Fatigue and Failure of Materials

Fatigue and damage tolerance in aerospace structures. Fatigue mechanism (macro and micro aspects), fatigue properties and strength, concept of stress concentration factor, effect of residual stresses, total-life approaches (stress-life, strain-life, fracture mechanics), effect of notches, constant and variable amplitude loading (cycle counting, damage summation, etc), multi-axial fatigue theories. Special topics on fatigue in composites will also be covered.

Suhasini Gururaja

References S Suresh, Fatigue of Materials, Cambridge University Press, 1991. J Schijve, Fatigue of Structures and Materials, Kluwer Academic Publ 2001. TL Anderson, Fracture Mechanics: Fundamentals and Applications, 3rd Edition, CRC Press 2005.

AE 253 (AUG) 3:0

Multi-body Dynamics Using Symbolic Manipulators

Computer-aided modeling and simulation of 3D motions of multi-body systems. Coupled, multibody kinematics and dynamics, reference frames, vector differentiation, configuration and motion constraints, holonomicity, generalized speeds, partial velocities and partial angular velocities, Rodrigues parameter, inertia dyadics, parallel axes theorems, angular momentum, generalized forces, energy integrals, momentum integrals, generalized impulses and momentum, exact closed –form and approximate numerical solutions. Comparing Newton/Euler's, Lagrange's and Kane's methods. Generation and solution of equations of motion using computer algorithms and software packages from amongst MotionGenesisTM Kane, AUTOLEVTM MATHAMATICA® and MATLAB®. Overview of flexible multi-body dynamics and applications in aerospace vehicular dynamics.

Dinesh Kumar Harursampath

References Kane, T., and Levinson, D., Dynamics Online: Theory and implementation with AUTOLEVTM. Online Dynamics Inc., Sunnyvale, CA, USA, 2000. Mitiguy, P. Advanced Dynamics and Motion Simulation, MotionGenesis, San Mateo, CA, USA, 2008. Wolfram, S., The Mathematica® book, Cambridge University Press, 5th Edition, 2003.

AE 272 (AUG) 3:0

Biologically inspired computing and its applications

Introduction, neural networks – different learning techniques, McCulloch-Pitts neuron, perceptrons, delta rule, multilayer perceptron networks, radial basis function network, self-organizing networks. Introduction to evolutionary computing and GA, GA terminology and operators (mutation, crossover, inversion). Selection, replacement and reproduction strategies. Fitness, proportional, random, and tournament and rank based selection. Swarm intelligence – basic ideas, swarm behavior, flocking, self-organization, adaptation, multi-agent systems, trail laying, self-assembling, task handling, combinatorial optimization. Applications of biologically inspired algorithms in engineering. Introduction, neural networks – different learning techniques, McCulloch-Pitts neuron, perceptrons, delta rule, multilayer perceptron networks, radial basis function network, self-organizing networks. Introduction to evolutionary computing and GA, GA terminology and operators (mutation, crossover, inversion). Selection, replacement and reproduction strategies. Fitness, proportional, random, and tournament and rank based selection. Swarm intelligence – basic ideas, swarm behavior, flocking, self-organization, adaptation, multi-agent systems, trail laying, self-assembling, task handling, combinatorial optimization. Applications of biologically inspired algorithms in engineering.

Prerequisite Working knowledge of MATLAB or any other programming language~References Bonabeau, E., Dorigo, M., and Theraulaz, G., Swarm Intelligence: From Natural to Artificial Systems, Oxford University Press, 1999. Simon Haykin, Neural Networks – A Comprehensive Foundation, 2nd Edition, Prentice-Hall, Inc., 1999. Michalewicz, Z., Genetic Algorithms+Data Structures=Evolution Programs, 3rd Edn, Springer-Verlag, Berlin, 1996.

AE 223 (AUG) 3:0

Hypersonic Flow Theory

Characteristic features of hypersonic flow, basic equations boundary conditions for inviscid flow, shock shapes over bodies, flow over flat plate, flow over a wedge, hypersonic approximations, Prandtl-Meyer flow, axisymmetric flow over a cone. Hypersonic small disturbance theory, applications to flow over a wedge and a cone, blast wave analogy, Newtonian impact theory, Busemann centrifugal correction and shock expansion method, tangent cone and tangent wedge methods. Introduction to viscous flows, hypersonic boundary layers, non-equilibrium high enthalpy flows. High enthalpy impulse test facilities and instrumentation. Computational fluid mechanics techniques for hypersonic flows, methods of generating experimental data for numerical code validation at hypersonic Mach numbers in hyper velocity facilities.

Gopalan Jagadeesh

Prerequisites AE 202, AE 222, Cherynl, C.G., Introduction to Hypersonic Flow, Academic Press, 1961. Hayes, W.D. and Problein, R.F., Hypersonic Flow Theory, Academic Press, 1959. Cox, R.N. and Crabtree, L.P., Elements of Hypersonic Aerodynamics, London, 1965.

AE 205 (AUG) 3:0

Navigation, Guidance and Control

Navigation: Continuous waves and frequency modulated radars, MTI and Doppler radars; Hyperbolic navigation systems: INS, GPS, SLAM; Guidance: Guided missiles, guidance laws: pursuit, LOS and PN laws, Guidance of UAVs; Control: Linear time invariant systems, transfer functions and state space modeling, analysis and synthesis of linear control systems, applications to aerospace engineering.

Debasish Ghose, Ashwini Ratnoo

References AE NGC Faculty, Lecture Notes . Skolnik, M. I., Introduction to Radar Systems, 2 nd edition , McGraw Hill Book Company. Bose A., Bhat, K. N., Kurian T ., Fundamentals of Navigation and Inertial Sensors , 1 st edition, Prentice-Hall India. Noureldin, A., Karamat, T. B., and Georgy, J ., Fundamentals of Inertial Navigation, Satellite-based Positioning and their Integration , 1 st edition , Springer. Nise, N.S., Control Systems Engineering, 6 th edition , John Wiley and Sons Inc. Shneydor, N. A., Missile Guidance and Pursuit: Kinematics, Dynamics and Control, 1 st edition , Horwood Publishing.

AE 262 (JAN) 3:0

Introduction to Helicopters

Hover, axial flight and autorotation, rigid blade flapping in forward flight, multi-blade coordinates, different reference planes. Helicopter quasi-steady and unsteady aerodynamics, rotor wake modeling and dynamic stall. Floquet theory, introduction to rotor control performance and vibration.

Helicopter design process.

Ranjan Ganguli

References Gessow, A., and Myers, G.C. Jr., Aerodynamics of the Helicopter. Frederick, Unger Publishing Co., New York, 1967. Leishman, G.J., Principles of Helicopter Aerodynamics, Cambridge University Press, 2000.

AE 258 (JAN) 3:0

Non - Destructive Testing and Evaluation

Fundamentals and basic concepts of NDT & E, Principles and applications of different NDE tools used for testing and evaluation of aerospace structures viz., ultrasonics, radiography, electromagnetic methods, acoustic emission, thermography. Detection and characterization of defects and damage in metallic and composite structural components.

Ramachandra Bhat M

Prerequisite AE 204 or equivalent,Reference Sharpe, R.A., Research Techniques in NDT, Metals Handbook -Vol.17.

AE 225 (JAN) 3:0

Boundary Layer Theory

Discussions on Navier-Stokes equation and its exact solutions, boundary layer approximations, two-dimensional boundary layer equations, asymptotic theory, Blasius and Falkner Skan solutions, momentum integral methods, introduction to axisymmetric and three-dimensional boundary layers, compressible boundary layer equations, thermal boundary layers in presence of heat transfer, higher-order corrections to the boundary layer equations, flow separation -breakdown of the boundary layer approximation and the triple deck analysis, transitional and turbulent boundary layers - introduction and basic concepts.

Sourabh Suhas Diwan

Prerequisites AE 202 or equivalent, Schlichting, H., Boundary Layer Theory, McGraw-Hill, 1968. Rosenhead (ed.), Laminar Boundary Layers, Clarendon Press, 1962. van Dyke, M., Perturbation Methods in Fluid Mechanics, Academic Press, 1964. Recent Literature.

AE 226 (JAN) 3:0

Turbulent Shear Flows

Origin of turbulence, laminar-turbulent transition, vortex dynamics, statistical aspects of turbulence, scales in turbulence, spectrum of turbulence, boundary layers, pipe flow, free shear layers, concepts of equilibrium and similarity, basic ideas of turbulence modeling, measurement techniques.

Joseph Mathew, Ramesh O N

Prerequisite AE 202 or equivalent.~References Tritton, D.J., Physical Fluid Dynamics, Oxford University Press. Tennekes, H. and Lumley, J., A First Course in Turbulence, M.I.T. Press. Townsend, A.A., The Structure of Turbulent Shear Flow, Cambridge Univ. Press.

AE 227 (JAN) 3:0

Numerical Fluid Flow

Introduction to CFD, equations governing fluid flow, hyperbolic partial differential equations and shocks, finite difference technique and difference equations, implicit difference formula, time discretization and stability, schemes for linear convective equation, analysis of time integration schemes, monotonicity, schemes for Euler equations, finite volume methodology. Introduction to unstructured mesh computations.

Balakrishnan N(CFD)

Prerequisite AE 202 or equivalent,Charles Hirsch, Numerical Computation of Internal and External Flows, Vols.1-2, Wiley-Interscience publication, 1990.

AE 241 (JAN) 3:0

Combustion

Thermodynamics of reacting systems. Chemical kinetics: equilibrium, analysis of simple reactions, steady-state and partial equilibrium approximations. Explosion theories; transport phenomena: molecular and convective transports. Conservation equations of multi-component, reacting systems. Premixed flames: Rankine-Hugoniot relations, theories of laminar premixed flame propagation, quenching and flammability limits. Diffusion flames: Burke-Schumann theory, laminar jet diffusion flame. Droplet combustion, turbulent combustion. Closure problem, premixed and nonpremixed turbulent combustion. Introduction to DNS and LES.

Lakshmisha K N

References Turns,S.R.,An Introduction to Combustion,McGraw-Hill,2000. Strehlow

AE 242 (JAN) 3:0

Aircraft Engines

Description of air breathing engines, propeller theory, engine propeller matching, piston engines, turbofan, turbo-prop, turbojet, component analysis, ramjets, velocity and altitude performance, thrust augmentation starting, principles of component design/selection and matching.

Sheshadri T S, Sivakumar D

References Zucrow, M.J., Aircraft and Missile Propulsion, Vols. I and II John Wiley, 1958. Hill, P.G., and Peterson, C.R., Mechanics and Thermodynamics of Propulsion, Addison Wesley, 1965. Shepherd, D.G., Aerospace Propulsion, American Elsevier Pub., 1972.

AE 243 (JAN) 3:0

Rocket Propulsion

Introduction to rocket engines, features of chemical rocket propulsion, rocket equation, thrust equation, quasi-one-dimensional nozzle flow, types of nozzles, thrust control and vectoring, aerothermochemistry, propellant chemistry, performance parameters, solid propellant rocket internal ballistics, components and motor design of solid propellant rockets, ignition transients, elements of liquid propellant rocket engines, and spacecraft propulsion.

References Sutton, G.P., Rocket Propulsion Elements, John Wiley and Sons, 2001. Barrare, M., et al., Rocket Propulsion, Elsevier Co., 1960. Huzel, D.K., and Huang, D.K., Modern engineering for design of liquid-propellant rocket engines, AIAA, 1992.

AE 352 (JAN) 3:0

Nonlinear Meachanics of Composites Structures

Introduction to classical geometrical and physical non-linearities and non-classical geometrophysical non-linearities in structural mechanics. Mechanics of composite lamina and laminates including response and failure as affected by nonlinearities. Variational asymptotic methods of constructing nonlinear composite beam, plate and shell theories. Non-classical effects resulting from non-linearities. Effects of nonlinearities on stability of thin-walled structures. Introduction to nonlinear finite element analysis including mixed formulations. Applications to engineering structures like pipes, springs and rotor blades.

Dinesh Kumar Harursampath

Prerequiste AE 252 or equivalent and consent of instructor~Hodges, D.H., Nonlinear Composites Beam Theory, Progress in Astronautics & Aeronautics Series, 2013. Berdichevsky, V.L., Variational Principles of Continuum Mechanics, I. Fundamentals & II. Applications. Interaction of Mechanics & Mathematics Series, Springer, 2009. Current literature in International Journal of Nonlinear Mechanics, International Journal of Solids and Structures etc.~~~

AE 353 (JAN) 3:0

Micro mechanics of Composites

Introduction to tensors, properties of tensors, concepts of isotropy and anisotropy, micromechanical homogenization theory, Eshelby's approach, self-consistent schemes, Mori-Tanaka Mean field theory, bounds on effective properties, concentric cylinder models, introduction to computational homogenization, introduction to damage mechanics, statistical aspects of microstructure

Suhasini Gururaja

Prerequisites Solid mechanics or equivalent and consent of instructor~References Micromechanics of defects in solids, T. Mura 1982 Micromechanics of composite materials, Brett Bendnarcyk et al, 2012 Open literature~~~

AE 271 (JAN) 3:0

Guidance Theory and Applications

Fundamentals of guidance; interception and avoidance; taxonomy of guidance laws, classical and empirical guidance laws; applied optimal control and optimal guidance laws; differentialgames and pursuit evasion problems. Recent advances in guidance theory. Collision detection and avoidance strategies. Applications to guided missiles. Unmanned aerial vehicles and mobile robots.

Debasish Ghose, Ashwini Ratnoo

Prerequisite AE 205 or equivalent~References Zarchan, P., Tactical and Strategic Missile Guidance, AIAA Publications, 4th Edition, 2002. G.M. Siouris, Missile Guidance and Control Systems, Springer Verlag, 2004. N.A.Sneyhdor, Missile Guidance and Pursuit, Ellis Horwood Publishers, 1998.~~~

AE 273 (JAN) 3:0

Unmanned Aerial Vehicles

History of Unmanned Air Vehicle (UAV) development. Unmanned aircraft systems: coordinate frames, kinematics and dynamics, forces and moments, lateral and longitudinal autopilots. UAV navigation: accelerometers, gyros, GPS. Path planning algorithms: Dubin's curves, way-points, Voronoi partitions.Path following and guidance: Straight line and curve following, vision based guidance; Future directions and the road ahead.

Ashwini Ratnoo

Prerequisites AE 201 and AE 205~References Randal W.Beard and Timothy W.McLain: Small Unmanned Aircraft: Theory and Practice, Princeton University Press, 2012Kimon P.Valavanis: Advances in Unmanned Aerial Vehicles: State of the Art and the Road to Autonomy, Springer, 2007.~~~

AE 371 (JAN) 3:0

Analysis and Synthesis of Dynamical Systems

Introduction and motivation; Review of linear algebra and matrix theory; Basic numerical methods in system theory; Solution of ordinary differential equations; State space representation of dynamical systems; Linearization of nonlinear systems; Time response of linear systems in state space form; Stability, Controllability and Observability of linear systems; Pole placement control design; Pole placement observer design; Linear Quadratic Regulator (LQR) for Linear time-invariant systems. Lyapunov stability theory for Autonomous nonlinear systems; Back-stepping design; Dynamic inversion (Feedback linearization); Optimal dynamic inversion for distributed parameter systems; Applications of neural networks in control system design; Neuro-adaptive control; Nonlinear observers; Lyapunov stability theory for Non-autonomous Systems; Adaptive control for uncertain dynamical systems.

Radhakant Padhi

Prerequisite Instructor consent and familiarity with MATLAB References Lecture Notes E. Kreyszig: Advanced Engineering Mathematics, 10th Ed., Wiley, 2015. J. M. Ortega: Matrix Theory: A Second Course, Springer, 2013 S. K. Gupta: Numerical Methods for Engineers, New Age International Pvt. Ltd., 2015. N. Nise: Control Systems Engineering, Wiley, 7 th Ed., 2015. K. Ogata: Modern Control Engineering, 5th Ed., Pearson, 2009. H. J. Marquez: Nonlinear Control Systems - Analysis and Design, Wiley, 2003. J-J E. Slotine and W. Li: Applied Nonlinear Control, Pearson, 1991. Current Literature~~~~

AE 372 (JAN) 3:0

Applied optimal Control and State Estimation

Introduction and Motivation; Review of static optimization; Calculus of variations and Optimal control formulation; Numerical solution of Two-point boundary value problems: Shooting method, Gradient method and Quasi-linearization; Linear Quadratic Regulator (LQR) design: Riccati solution, Stability proof, Extensions of LQR, State Transition Matrix (STM) solution; State Dependent Riccati Equation (SDRE) design; Dynamic programming: HJB theory; Approximate dynamic programming and Adaptive Critic design; MPSP Design and Extensions; Optimal State Estimation: Kalman Filter, Extended Kalman Filter; Robust control design through optimal control and state estimation; Constrained optimal control systems: Pontryagin minimum principle, Control constrained problems, State constrained problems; Neighbouring extremals and Sufficiency conditions; Discrete Time Optimal Control: Generic formulation, Discrete LQR.

Radhakant Padhi

Prerequisites Instructor consent; AE 371 or equivalent recommended~References Lecture Notes D. S. Naidu: Optimal Control Systems, CRC Press, 2002. A. Sinha: Linear Systems: Optimal and Robust Control, CRC Press, 2007. A. E. Bryson and Y-C Ho: Applied Optimal Control, Taylor and Francis, 1975. R. F. Stengel: Optimal Control and Estimation, Dover Publications, 1994. A. P. Sage and C. C. White III: Optimum Systems Control (2nd Ed.), Prentice Hall, 1977. D. E. Kirk: Optimal Control Theory: An Introduction, Prentice Hall, 1970. F. L. Lewis: Optimal Control, Wiley, 1986. Current Literature~~~

AE 373 (JAN) 3:0

Cooperative Control with Aerospace Applications

Introduction to cooperative control, mathematical preliminaries: algebraic graph theory, matrices for cooperative control, stability of formations. Consensus algorithms, consensus for single and double integrator dynamics, consensus in position, direction, and attitude dynamics. Distributed multi-vehicular cooperative control. Generalized cyclic pursuit; spacecraft formation flying. UAV applications in search, coverage, and surveillance of large areas, and in monitoring and controlling of hazards. Routing and path planning of UAVs. Role of communication. Operation in uncertain environments and uncertainty.

Debasish Ghose

References Shamma, J. (ed), Cooperative Control of Distributed Multi-Agent Systems, John Wiley, 2008. Qu, Z., Cooperative Control of Dynamical Systems, Springer Verlag, 2009. Ren, W., and Beard, R., Distributed Consensus in Multi-vehicle Cooperative Control: Theory and Applications, Springer, 2007. Rasmussen, S., and Shima, T. (Eds.), UAV Cooperative Decision and Control: Challenges and Practical Approaches, SIAM Publications, 2008.~~~~

AE 211 (JAN) 3:0

Mathematical methods for aerospace engineers

Applied linear algebra and probability theory; Boundary value problems, Finite differences, and finite elements ; Fouries series, integrals, DFTs and FFTs; Initial value problems and their numerical solution; Solution of sparse systems; Calculus of variations and adjoint methods.

Kartik Venkatraman

References G. Strang. Computational Science and Engineering. Wellesley-Cambridge Press, Wellesley, MA, USA, 2007. G. Strang. Introduction to Applied Mathematics. Wellesley-Cambridge Press, Wellesley, MA, USA, 1986.

AE 221 (JAN) 3:0

Aerodynamics

Introduction to aerodynamics, potential flows, conformal mapping and Joukowski airfoils, Kutta condition, thin airfoil theory, viscous effects and high-lift flows, lifting line theory, vortex lattice method, delta wings, compressibility effect, supersonic flows, unsteady aerodynamics.

Balakrishnan N(CFD), Ramesh O N

Prerequisite AE 202~References Houghton, E.L. and Carpenter, P.W., Aerodynamics for Engineering Students, Butterworth-Heinemann, 2003. Katz, J. and Plotkin, A., Low-speed Aerodynamics, Cambridge, 2001. Bertin, J.J. and Smith, M.L., Aerodynamics for Engineers, Prentice-Hall, 1989.

AE 222 (JAN) 3:0

Gas Dynamics

Fundamentals of thermodynamics, propagation of small disturbances in gases, normal and oblique shock relations, nozzle flows, one-dimensional unsteady flow, small disturbance theory of supersonic speeds, generation of supersonic flows in tunnels, supersonic flow diagnostics, supersonic flow over two-dimensional bodies, shock expansion analysis, method of characteristics, one-dimensional rarefaction and compression waves, flow in shock tube.

Joseph Mathew, Gopalan Jagadeesh, Srisha Rao M V

Prerequisite AE 202~References Liepmann, H.W. and Roshko, A., Elements of Gas Dynamics, John Wiley, 1957. Becker, E., Gas Dynamics Academic Press, New York, 1968.

AE 224 (JAN) 3:0

Advanced Fluid Dynamics

Viscosity, stress tensor, Navier-Stokes equations, boundary conditions. Parallel flows in ducts, Stokes/Rayleigh problems, laminar boundary layers, viscous compressible flow. Nature of turbulent flows, Reynolds decomposition and equations, turbulence modelling and computation, free shear and wall-bounded flows, DNS/LES.

Joseph Mathew

Prequisites AE 202 or equivalent~References White, F.M., Viscous Fluid Flow, McGraw-Hill, 2005. Kundu, P.K., Cohen, I.M. and Dowling, D.R., Fluid Mechanics, Academic Press, 2016. Pope, S.B., Turbulent Flows, Cambridge, 2000.

AE 229 (JAN) 3:0

Computational Gas Dynamics

Governing equations of compressible fluid flows, classification of partial differential equations, analysis of hyperbolic conservation laws, basics of discretization, finite difference and finite volume methods, numerical diffusion, numerical methods for scalar and vector conservation laws, central and upwind discretization methods, flux splitting methods, Riemann solvers, kinetic (Boltzmann) schemes, relaxation schemes.

Raghurama Rao S V

Prerequisites AE 202, AE 222, courses in Numerical Analysis/Numerical Methods, and any programming language.~References Laney, B., Computational Gas Dynamics. Toro, E.F., Riemann Solvers and Numerical Methods for Fluid Dynamics. Godlewski, E., and Raviart, P., Numerical Approximation of Hyperbolic System of Conservation Laws.

AE 230 (JAN) 3:0

Numerical Grid Generation and flow

Basics of fluid dynamics, gas dynamics, governing equations of fluid dynamics, various levels of approximation, partial differential equations, basics of discretization, finite difference, finite volume methods, mesh-less methods, space marching and time marching approaches, geometrical complexities for mesh generation, methods of mesh generation, examples of simple flow computations

References J.C., Anderson, D.A. and Fletcher, R.H., Computational Fluid Mechanics and Heat Transfer. Anderson, Computational Fluid Dynamics - Basics and applications. Joe Thompson, Numerical Grid Generation.

AE 299 (JAN) 0:20

Dissertation Project

The M.E. project is aimed at training the students to analyse independently any problem posed to them. The project may be a purely analytical piece of work, a completely experimental one or a combination of both. In a few cases, the project may also involve a sophisticated design work. The project report is expected to show clarity of thought and expression, critical appreciation of the existing literature and analytical and/or experimental or design skill.

Gopalakrishnan S

Dissertation Project,Dissertation Project,Dissertation Project

AE 321 (JAN) 3:0

Hydrodynamic Stability

Hydrodynamic stability theory for laminar-turbulent transition. Linearized flow equations, normal mode analysis, the eigenvalue problem (EVP) and instability criteria: Rayleigh equation, discussion of Kelvin- Helmholtz and other instabilities. Boundary layer stability: Orr-Sommerfeld equations, Tollmien-Schlichting waves, dual role of viscosity. Introduction to spatio-temporal, absolute and convective instabilities, secondary instability theories. Weakly non-parallel shear flow instability: parabolized stability equation (PSE) methods, extensions to include nonlinearity. Global stability theory, non-parallel two and three-dimensional flow with multiple inhomogeneous directions. Nonmodal treatment of hydrodynamic stability as an initial value problem (IVP), optimal perturbations.

Arnab Samanta

Prerequisite AE 202 or equivalent and consent of Instructor,Schmid, P. and Henningson, D., Stability and transition in shear flows, Springer, 2001. Drazin, P.G. and Reid, W.H., Hydrodynamic stability, Cambridge University Press, 2004. Recent Literature.

AE 322 (JAN) 3:0

Aeroacoustics

Review of classical acoustics: linearized equations of motion; classical wave equation: plane and spherical waves, wave propagation in homogeneous and inhomogeneous media; models for acoustic sound sources: point sources, monopoles, dipoles and quadrupoles, Green's function solutions for wave equations, Kirchhoff-Helmholtz theorem for rigid boundaries. Aeroacoustic sources: Lighthill's acoustic analogy, integral solutions and far-field approximations; effect of solid surface: Curle's theory and Ffowcs Williams-Hawkings' equation. Computational approaches: numerical aspects; direct methods: Reynolds-averaged Navier-Stokes equations (RANS), direct numerical simulations (DNS), application of large eddy simulations (LES); hybrid methods: flow-sound separation, numerical evaluation of Lighthill's integral.

Arnab Samanta

Pre requisite AE 202 or equivalent and consent of instructor.,References Pierce, A.D., Acoustics, Acoustical Society of America, 1989. Howe, M.S., Theory of Vortex sound, Cambridge, 2003. Crighton, D.G., Basic principles of aerodynamic noise generation, Prog. Aerospace Sci., 16(1), 1975, pp. 31-96. Crighton, D.G., Dowling, A.P.,Ffowcs Williams, J.E., Heckl, M. and Leppington, F.G., Modern methods in analytical acoustics, Springer, 1992.

AE 251 (JAN) 3:0

Energy and Finite Element Methods

Introduction to Energy Methods; Principle of Virtual Work, Principle of Minimum Potential Energy, Raleigh Ritz Method, Hamilton's Principle. Introduction to Variational Methods, Weak form of Governing Equation, Weighted residual method, Introduction to Finite elements, and Galerkin Finite elements. Finite Element Method - Various element formulations for metallic and composite structures, isoparametric element formulation, Numerical Integration, concept of consistency, completeness and mesh locking problems. Finite element methods for structural dynamics and wave propagation, Mass and damping matrix formulation, Response estimation through modal methods, direct time integration, Implicit and Explicit Methods. Introduction to super convergent finite element formulation and spectral finite elements.

Gopalakrishnan S

Prerequisite AE 204 or ME 242 or CE 214 and knowledge of MATLAB,References Cook, R.D., Malkus, D.S., and Plesha, M.E., Finite Element Analysis, John Wiley & Sons, New York, 1995. Bathe, K.J., Finite Element Procedures, Prentice Hall, New York, 1996. Varadan, V.K., Vinoy, K.J., and Gopalakrishnan, S., Smart Material Systems and MEMS, John Wiley & Sons, UK, 2006. Gopalakrishnan, S., Chakraborty, A., and Roy Mahapatra, D., Spectral Finite Elements, Springer Verlag, UK, 2008.~~~~

AE 252 (JAN) 3:0

Analysis and Design of Composite Structures

Introduction to composite materials, concepts of isotropy vs. anisotropy, composite micromechanics (effective stiffness/strength predictions, load-transfer mechanisms), Classical Lamination Plate theory (CLPT), failure criteria, hygrothermal stresses, bending of composite plates, analysis of sandwich plates, buckling analysis of laminated composite plates, inter-laminar stresses, First Order Shear Deformation Theory (FSDT), delamination models, composite tailoring and design issues, statics and elastic stability of initially curved and twisted composite beams, design of laminates using carpet and AML plots, preliminary design of composite structures for aerospace and automotive applications. Overview of current research in composites.

Narayana Naik G, Dinesh Kumar Harursampath

References Gibson, R.F., Principles of Composite Material Mechanics, CRC Press, 2nd Edition, 2007. Jones, R.M., Mechanics of Composite Materials, 2nd Edition, Taylor & Francis, 2010 (Indian Print). Daniel, I.M., and Ishai O., Engineering Mechanics of Composite Materials, Oxford University Press, 2nd Edition, 2005. Reddy, J.N., Mechanics of Laminated Composite Plates and Shells – Theory and Analysis, CRC Press, 2nd Edition, 2004.

AE 255 (JAN) 3:0

Aeroelasticity

Effect of wing flexibility on lift distribution; Torsional wing divergence; Vibration of single, two, and multi-degree of freedom models of wing with control surfaces; Unsteady aerodynamics of oscillating airfoil; Bending-torsion flutter of wing; Gust response of an aeroelastic airplane; Aeroservoelasticity of wing with control surfaces.

Kartik Venkatraman

References,Wright, J.R., and Cooper, J.E., Introduction to Aircraft Aeroelasticity and Loads, John Wiley, 2008. Hodges, D.H., and Alvin Pierce, G., Introduction to Structural Dynamics and Aeroelasticity, Cambridge University Press, 2002. Fung, Y.C., An Introduction to the Theory of Aeroelasticity, Dover edition, 2002. Bisplinghoff, R.L., Ashley, H., and Halfman, R.L., Aeroelasticity, Dover edition, 1996.

AE 256 (JAN) 3:0

Wave Propagation in Structures

Structural dynamics and wave propagation, continuous and discrete Fourier transform, FFT, sampled wave forms, spectral analysis of wave motion, propagating and reconstructing waves, dispersion relations, signal processing and spectral estimation, longitudinal wave propagation in rods, higher order rod theory, flexural wave propagation in beams, higher order beam theories, wave propagation in complex structures, spectral element formulation, wave propagation in two dimensions, wave propagation in plates.

Gopalakrishnan S

References Doyle, J.F., Wave propagation in Structures, Springer Verlag, New York, 1989. Grof, K.F., Wave motion in Elastic Solids, Dover, New York, 1975.

AE 257 (JAN) 3:0

Engineering Optimization

Constrained and unconstrained minimization of linear and nonlinear functions of one or more variables, necessary and sufficient conditions in optimization, KKT conditions, numerical methods in unconstrained optimization, one dimensional search, steepest descent and conjugate gradient methods, Newton and quasi-Newton methods. Finite difference, analytical and automatic differentiation, linear programming, numerical methods for constrained optimization, response surface methods in optimization, orthogonal arrays, stochastic optimization methods.

Ranjan Ganguli

Reference Ranjan Ganguli, Engineering Optimization: A Modern Approach, Universities Press, 2010.

AE 259 (JAN) 3:0

Rotary Wing Aeroelasticity

Review of structural dynamics. Dynamics of rotating beams: hinged rigid blades, elastic blades, rotor speed characteristics and fan plots, blades in flap, lag and torsion. Aerodynamic loads, forced response and vibration, harmonic balance method, finite element in time. Vehicle trim. Stability analysis methods: constant coefficients, Floquet theory. Blade aeroelastic instabilities.

Ground resonance and air resonance.

Ranjan Ganguli

References Bielawa, R.L., Rotary Wing Structural Dynamics and Aeroelasticity, AIAA Education Series, 1992. Johnson, W., Helicopter Theory, Dover, 1994. Bramwell, Done, Balmford, Bramwell's Helicopter Dynamics, Butterworth-Heineman, 2001.

AE 260 (JAN) 3:0

Modal Analysis: Theory and Applications

Introduction to modal testing and applications, Frequency Response Function (FRF) measurement, properties of FRF data for SDOF and MDOF systems, signal and system analysis, modal analysis of rotating structures; exciters, sensors application in modal parameter (natural frequency, damping and mode shape) estimation. Vibration standards for human and machines, calibration and sensitivity analysis in modal testing, modal parameter estimation methods, global modal analysis methods in time and frequency domain, derivation of mathematical models – modal model, response model and spatial models. Coupled and modified structure analysis. Application of modal analysis to practical structures and condition health monitoring.

Siddanagouda Kandagal

References Ewins, D.J., Modal analysis: Theory and Practice, Research Studies Press Ltd., England, 2000. Clarence W. de Silva, Vibration: Fundamentals and Practice, CRC press New York, 1999 G. McConnel, Vibration testing: Theory and Practice, John Wiley & Sons, Inc., New York, 1995.

AE 263 (JAN) 3:0

Advanced Flight and Space Mechanics

Review of equations of motion, stability derivative estimation, static stability and control, longitudinal and lateral modes, transfer function and response characteristics, feedback and automatic control, response to atmospheric gust and turbulence. Handing qualities, human pilot modelling case studies of typical airplanes, roll and spin characteristics, flight simulators, stability and control derivative estimation from wind tunnel and flight tests.

Dinesh Kumar Harursampath, Radhakant Padhi

Prerequisite AE 201 or equivalent~References Babistor, A.H., Aircraft Stability and Control, Pergamon Press. Elkin, B., Dynamics of Atmospheric Flight, John Wiley and Sons. Mcroer D Ashikenbars I and Graham D., Aircraft Dynamics and Automatic Control, Princeton University Press. ESDU Data Sheets~~~

Centre for Atmospheric and Oceanic Sciences

M Tech Programme in Climate Science

(Duration: 2 years
Total Credits: 64)

Core Courses: 24 Credits

AS 202 3:0	Geophysical Fluid Dynamics
AS 203 3:0	Atmospheric Thermodynamics
AS 204 3:0	Atmospheric Radiation and Climate
AS 205 2:1	Ocean Dynamics
AS 207 3:0	Introduction to Atmoshphric Dynamics
AS 211 3:0	Observational Techniques
AS 216 3:0	Introduction to Climate System

One 3:0 credit Mathematics Course offered at (SERC/ Maths/CHE/CAOS/CEas)

Project: 28 Credits

Elective: A balance of 15 credits required to make up a minimum of 64 credits for completing the M Tech Programme.

AS 203 (AUG) 3:0

Atmospheric Thermodynamics

Vertical structure and composition of the atmosphere, kinetic theory of gases, first and second principles of thermodynamics, thermodynamics of dry air, concept of saturation vapour pressure, water vapour in the atmosphere, properties of moist air, isobaric and isothermal processes, atmospheric stability, parcel and area methods, nucleation, effect of aerosols, clouds and precipitation, forms of atmospheric convection.

Arindam Chakraborty

Iribarne, I.V., and Godson, W.I., Atmospheric Thermodynamics, 2nd Edn, D Reidel Publishing Company, 1971,Rogers, R.R., A Short Course in Cloud Physics, 2nd Edition, Pergamon Press, 1979,Bohren, C.F., and Albhecht, B.A., Atmospheric Thermodynamics, Oxford University Press, 1998,Tsonis, A.A., An Introduction to Atmospheric Thermodynamics, Cambridge University Press, 2002,Wallace, J.M., and Hobbs, P.V., Atmospheric Science – An Introductory Survey, 2nd Edn, Academic Press, 2006.

AS 207 (AUG) 3:0

Introduction to Atmospheric Dynamics

Introduction to weather and climate. Momentum, continuity and thermodynamic energy equations. Basic equations in isobaric coordinates. Balanced flow: inertial flow, cyclostrophic flow. Thermal wind, calculation of vertical velocities, circulation and vorticity. Planetary boundary layer: atmospheric turbulence, Boussinesq approximation. Introduction to quasi-geostrophic systems. Atmospheric waves.

Jai Suhas Sukhatme

Holton,J.R.,An Introduction to Dynamic Meteorology,4th Edn,Elsevier

AS 204 (AUG) 3:0

Atmospheric Radiation and Climate

Black body radiation, properties of surfaces, Kirchoff's law, radiative transfer in gases, solar radiation, terrestrial radiation, Rayleigh and Mie scattering, aerosols, vertical thermal structure, radiation budget, cloud forcing, and simple climate models.

Srinivasan J , Satheesh S K

Scheme of Instruction 2016 Page 183,Petty, G.W., A first course in Atmospheric Radiation, Sundog Publishing, Madison, Wisconsin, 2nd edition, 2006,Liou, K.N., Introduction to Atmospheric Radiation, Academic Press, San Diego, 2nd edition, 2002.

AS 205 (AUG) 2:1

Ocean Dynamics

Introduction to physical oceanography, properties of sea water and their distribution, mixed layer, barrier layer, thermocline, stratification and stability, heat budget and air-sea interaction, ocean general circulation, thermohaline circulation, basic concepts and equations of motion, scale analysis, geostrophic currents, wind-driven ocean circulation, Ekman layer in the ocean, Sverdrup flow, vorticity in the ocean, waves in the ocean, surface gravity waves, Rossby and Kelvin waves.

Vinayachandran P N

Talley et al., Descriptive Physical Oceanography,6th Edition, 2011,B. Cushman-Roising, Introduction to GFD,Introduction to Physical Oceanography,http:/eanworld.tamu.edu (online book)

AS 211 (JAN) 2:1

Observational Techniques

Principles of measurement and error analysis, fundamentals of field measurements, in situ measurement of atmospheric temperature, humidity, pressure, wind, radiation, precipitation and aerosols. Tower based techniques and automatic measurement systems. Upper air observations, radiosonde techniques. Measurements in the ocean, CTD, ADCP and ARGO. Modern measurement techniques

Bhat G S, Satheesh S K

Guide to Meteorological Measurements and Methods of Observation,,World Meteorological Organization Publication No. 8,,7th Edition, WMO, Geneva.radiative transfer, the role of radiation in climate.

AS 202 (JAN) 3:0

Geophysical Fluid Dynamics

Large-scale, slowly evolving flows on a rotating earth. Vorticity, potential vorticity (pv), consequences of pv conservation. Poincare, Kelvin and Rossby waves. Rotating shallow water equations, effects of stratification and the rotating-stratified Boussinesq equations. Quasi-geostrophic flow and pv, Rossby waves on the mid-latitude beta plane. Basic concepts of tropical dynamics.Waves, jets and undercurrents on the equatorial beta plane. Waves and large- scale flow in the atmosphere and ocean from observations.

Debasis Sengupta, Jai Suhas Sukhatme

Pedlosky, J., Geophysical Fluid Dynamics, Springer Verlag, 1977,Gill, A., Atmosphere and Ocean Dynamics, Academic Press Inc., 1982.,Holton,J.R., An Introduction to Dynamic Meteorology, Academic Press, 1992. Relevant Journal Articles

AS 208 (JAN) 3:0

Satellite Meteorology

Introduction to radiative transfer, radiative properties of surface, radiative properties of the atmosphere, scattering of radiation, image analysis. Thermal, infrared and microwave techniques for measurement of temperature, humidity and cloud height. Atmospheric sounders, limb sounding, radiation budget.

Srinivasan J , Satheesh S K

Kidder, S.Q., and Vonder Haar, T.R., Satellite Meteorology, Academic Press, 1995,Houghton, J.T., Taylor, F.W., and Rodgers, C.D.,,Remote Sensing of Atmosphere, Cambridge Univ. Press, 1984

AS 209 (JAN) 3:0

Mathematical Methods in Climate Science

Review of probability and statistics: probability distributions, sample statistics. Confidence intervals. Hypothesis testing; goodness of fit tests, time-series analysis: Fourier transforms, principal component analysis (PCA).

Venugopal Vuruputur

Papoulis, A., & U. Pillai, Probability, Random Variables and Stochastic Processes, 4th edition, McGraw Hill, 2002.,Wilks, D., Statistical Methods in the Atmospheric Sciences, 2nd edition, Academic Press, 2006.,O. Brigham, Fast Fourier Transforms, Prentice Hall, First Edition, 1974.,Press, W. H., S. A. Teukolsky, W. T. Vetterling, and B. P. Flannery, Numerical Recipes in C/Fortran: The Art of Scientific Computing, 3rd Ed., Cambridge Univ. Press, 2007

AS 210 (JAN) 3:0

Numerical methods in atmospheric modeling

Equations used in atmospheric modelling; numerical discretization techniques: finite difference, finite volume, spectral techniques, temporal discretization; modelling of sub-grid scale processes (cumulus parameterization and boundary layer parameterization); algorithms for parallel computation.

Ashwin K Seshadri

Thomas T Warner,Numerical Weather and Climate Prediction,Cambridge University Press,2011,John B Drake

AS 299 (JAN) 0:28

Project

Dept of Civil Engineering

M Tech Programmes
Geotechnical Engineering

Hard Core: 24 Credits (All courses are mandatory)

CE 201 3:0 Basic Geomechanics
CE 202 3:0 Foundation Engieering
CE 203 3:0 Earth and Earth Retaining Structures
CE 204 3:0 Foundation Engineering
CE 205 3:0 Geoenvironmental Engineering
CE 206 3:0 Ground Improvement and Geosynthetics

One 3:0 credit core course from either the Structural Engineering or the Water Resources and Environmental Engineering streams
A suitable 3:0 credit mathematics course will be identified by the department at the beginning of the term.

Project: 22 Credits
CE299 0:22 Dissertation Project
Electives: 18 Credits, of which at least 9 credits must be from among the group electives listed below.

CE 231 2:0 Soil Stabilization by Admixtures
CE 232 2:0 Fundamentals of Soil Behaviour
CE 234 2:0 Soil Dynamics
CE 236 2:1 Behaviour and Testing of Unsaturated Soils
CE 237 2:0 Rock Mechanics
CE 239 3:0 Computational Geotechnics
CE 240 3:0 Engineering Seismology
CE 241 3:0 Introduction to the theory of Plasticity
CE 242 3:0 Probabilistic Methods in Civil Engineering
CE 266 3:0 Pavement Engineering

Water Resources and Environmental Engineering

Hard Core: 24 Credits (All courses are mandatory)
CE 207 3:0 Computational Fluid Dynamics in Water Resources Engineering
CE 208 3:0 Surface Water Hydrology
CE 209 3:0 Ground Water and Contaminant Hydrology
CE 210 3:0 Systems Techniques in Water Resources & Environmental Engineering.
CE 211 3:0 Water Quality Modeling
CE 212 3:0 Design of Water Supply and Sewerage Systems

One 3:0 credit core course from either the Geotechnical Engineering or the Structural Engineering streams
A suitable 3:0 mathematics course will be identified by the department at the beginning of the term.

Project: 22 Credits
CE299 0:22 Dissertation Project
Electives: 18 Credits, of which at least 9 credits must be from among the group electives listed below.
CE 255 3:0 Urban Hydrology
CE 256 3:0 Stochastic Hydrology
CE 258 3:0 Remote Sensing and GIS for Water Resources and Environmental Engineering
CE 259 3:0 Regionalization in Hydrology and Water Resources Engineering.
ME 201 3:0 Fluid Mechanics
AS216 3:0 Introduction to Climate Systems

Structural Engineering
Hard Core: 24 Credits (All courses are mandatory)
CE 214 3:0 Solid Mechanics
CE 215 3:0 Mechanics of Structural Concrete
CE 216 3:0 An Introduction to Finite Elements in Solid Mechanics
CE 217 3:0 Linear Structural Dynamics
CE 218 3:0 Optimization Methods
CE 219 3:0 Stability of Structures

One 3:0 core course from either the Geotechnical Engineering or the Water Resources and Environmental Engineering streams
A suitable 3:0 credit mathematics course will be identified by the department at the beginning of the term.

Project: 22 Credits
CE 299 0:22 Dissertation Project
Electives: 18 Credits of which at least 9 credits must be from among the group electives listed below.

CE 273 3:0 Fracture Mechanics
CE 275 3:0 Nonlinear FEM in Structural Engineering
CE 276 3:0 Structural Masonry
CE 287 3:0 Stochastic Structural Dynamics
CE 291 3.0 Uncertainty Modelling and Analysis
CE 294 3:0 Monte Carlo Simulations in Structural Mechanics

M Tech Programme in Transportation and Infrastructure Engineering

Hard Core: 25 Credits (All courses are mandatory)

CE 266 3:0 Pavement Engineering
CE 212 3:0 Design of Water Supply and Sewerage Systems
CE 263 3:0 Modelling Transport and Traffic
CE 218 3:0 Optimization Methods
MG 223 3:0 Applied Operations Research
ST 210 3:1 Principles and Applications of GIS and Remote Sensing
MA 261 3:0 Probability Models
MG 221 2:1 Applied probability and Statistics
MG 226 3:0 Regression and Time series analysis

Project: 22 credits

CE 299 0:22 Dissertation Project

Electives: 18 Credits of which at least 9 credits should be from among the electives listed below.

CE 204 3:0 Foundation Engineering
CE 206 3:0 Ground Improvement and Geosynthetics
CE 267 3:0 Transportation Statistics and Micro-simulation
CE 215 3:0 Mechanics of Structural Concrete
CE 216 3:0 Introduction to Finite Elements in Solid Mechanics
ST 202 3:0 Renewable Energy – Technology, Economics and Environment
ST 203 3:0 Technology and Sustainable evelopment

CE 236 (AUG) 3:0

Fracture Mechanics

Chandra Kishen J M

CE 211 (AUG) 3:0

Mathematics for Engineers

Revision of ordinary linear ODEs, Formal operators, Adjoint operator, Sturm-Liouville theory, eigenvalue problems, Classification of PDEs, Characteristics / first order PDEs, Laplace equation / potential theory, Separation of variables (cartesian, polar), Eigenfunction expansions, Green's functions, Introduction to boundary value problems

Probability space and axioms of probability. Conditional probability. Total probability and Bayes theorems. Scalar and vector random variables. Probability distribution and density functions. Expectation operator. Functions of random variables.

Vector spaces and subspaces, solution of linear systems, Linear independence, basis, and dimension, The four fundamental subspaces, Linear transformations, Orthogonal vectors and subspaces, Cosines and projections onto lines, Projections and least squares, The fast Fourier transform, Eigenvalues and eigenvectors, Diagonalization of a matrix, Difference equations and powers of matrices, Similarity transformations.

Manohar C S, Debraj Ghosh

Michael Stone,Paul Goldbart,2009,Mathematics for Physics: A Guided Tour for Graduate Students,Cambridge University Press~A Papoulis and S U Pillai

CE 274 (AUG) 3:0

Sustainable Urban Transportation Planning

Concept of sustainability and its relevance to urban transport; Introduction to Sustainable Transport; Indicators of Sustainable Transport; modelling and analytical techniques to measure and analyze sustainability of transportation projects and policies; Urban and Land use planning for Sustainable Transport; Modelling and Planning for Public transport, and Non-Motorized Transport; impact of factors related to perception/aspirations, travel behaviour, on development and promotion of sustainable transport.

Ashish Verma

Gudmundsson H; Hall RP; Marsden G; Zietsman J (2015) Sustainable Transportation Indicators, Frameworks, and Performance Management, Springer. A. Gautam et al. (eds.), Sustainable Energy and Transportation, Springer, pp.9-20.~Verma A., (2012), "Quantifying Sustainability to Assess Urban Transportation Policies and Projects". Indian Journal of Transport Management, Vol.36, No.4, pp.254-272.~Verma A., Sreenivasulu S., and Dash N. (2011), "Achieving Sustainable Transportation System for Indian Cities - Problems and Issues". Current Science, Vol. 100, No. 9, pp.1328-1339

CE 220 (AUG) 3:0

Design of Substructures

Design considerations, field tests for bearing capacity and settlement estimates, selection of design parameters. Structural design considerations. Codes of practice. Design of spread footings, combined footings, strap footings, ring footings, rafts, piles and pile caps and piers.

Raghuveer Rao P

Bowles~J.E. Foundation analysis and design. 5th Edn.~McGraw Hill~1996Indian Standard Codes

CE 221 (AUG) 3:0

Earthquake Geotechnical Engineering

Introduction to engineering seismology. Plate tectonics. Earthquake magnitude. Ground motion. Effect of local soil conditions on ground motion. Dynamic behaviour of soils. Analysis of seismic site response. Liquefaction phenomena and analysis of pore pressure development. Laboratory and in-situ testing for seismic loading. Analysis and design of slopes, embankments, foundations and earth retaining structures for seismic loading. Case histories. Mitigation techniques and computer-aided analysis

Gali Madhavi Latha

Geotechnical Earthquake Engineering By Steven L. Kramer, Pearson Education, 2003.~Geotechnical Earthquake Engineering Handbook, Robert W. Day, McGraw-Hill, 2002.~Current Literature

CE 247 (AUG) 3:0

Remote Sensing and GIS for Water Resources Engineering

Basic concepts of remote sensing. Airborne and space borne sensors. Digital image processing. Geographic Information System. Applications to rainfall - runoff modeling. Watershed management. Irrigation management. Vegetation monitoring. Drought and flood monitoring, Environment and ecology. Introduction to digital elevation modeling and Global Positioning System (GPS). Use of relevant software for remote sensing and GIS applications.

Nagesh Kumar D

Lillesand T.M.~and Kiefer R.W.~Remote Sensing and Image Interpretation~John Wiley & Sons~2000.

CE 245 (AUG) 3:0

Design of Water Supply and Sewerage Systems

Basics of hydraulics and hydrology. Introductory chemistry and biology. Water distribution systems, water processing, and operation of networks. Design of water supply units, wastewater flows and collection systems, wastewater processing. Advanced wastewater treatment and water reuse.

Mohan Kumar M S

Mark J Hammer & Mark J Hammer Jr.,Water and Wastewater Technology,Fifth Edition,Pearson Prentice Hall,Columbus

CE 220 (AUG) 3:0

Design of Substructures

Design considerations, field tests for bearing capacity and settlement estimates, selection of design parameters. Structural design considerations. Codes of practice. Design of spread footings, combined footings, strap footings, ring footings, rafts, piles and pile caps and piers.

Raghuveer Rao P

Bowles,J.E. Foundation analysis and design. 5th Edn.,McGraw Hill,1996Indian Standard Codes

CE 249 (AUG) 3:0

Water Quality Modeling

Basic characteristics of water quality, stoichiometry and reaction kinetics. Mathematical models of physical systems, completely and incompletely mixed systems. Movement of contaminants in the environment. Water quality modeling in rivers and estuaries - dissolved oxygen and pathogens. Water quality modeling in lakes and ground water systems.

Sekhar M

Chapra,S.C.,Surface Water Quality Modeling,McGraw Hill,1997.

CE 202 (AUG) 3:0

Foundation Engineering

Bearing capacity of shallow foundations, penetration tests, plate load tests. Settlement of shallow foundations, elastic and consolidation settlements; settlement, estimates from penetration tests, settlement tolerance. Allowable bearing pressure. Foundations on problematic soils. Principles of foundation design. Introduction of deep foundations. Bearing capacity and settlement of piles and pile groups in soils. Machine foundations. Reinforced soil beds

Sitharam G Thallak

Bowles,J.W.,Foundation Analysis and Design,5th Edn.,McGraw-Hill

CE 203 (AUG) 3:0

Surface Water Hydrology

Review of basic hydrology, hydrometeorology, infiltration, evapotranspiration, runoff and hydrograph analysis. Flood routing – lumped, distributed and dynamic approaches, hydrologic statistics, frequency analysis and probability, introduction to environmental hydrology, urban hydrology. Design issues in hydrology.

Srinivas V V

Bedient,P. B.,and Huber,W. C.,Hydrology and Floodplain Analysis

CE 201 (AUG) 3:0

Basic Geo-mechanics

Introduction to genesis of soils, basic clay mineralogy; Principle of effective stress, permeability and flow; Fundamentals of Tensors, Introduction to stresses and deformation measures; Mohr-Coulomb failure criteria, soil laboratory tests; Critical state and stress paths. Shear Strength and Stiffness of Sands; Consolidation, shear strength and stiffness of clays

Tejas Gorur Murthy

Wood,D.M.,Soil Behaviour and Critical State Soil Mechanics,Cambridge University Press,1991.

CE 231 (AUG) 3:0

Forensic Geotechnical Engineering

Introduction, Definition of a Forensic Engineer, Types of Damage, Planning the Investigation, investigation methodology, Collection of Data, Distress Characterization, Development of Failure, Hypothesis, Diagnostic Tests, Back Analysis, Technical Shortcomings, Legal Issues Reliability Aspects, Observation Method of Performance Evaluation, Case Histories related to settlement of Structures, lateral movement, backfill settlements, causes due to soil types such as collapsible soil, expansive soil, soluble soils, slope Failures and landslides, debris flow, slope softening and creep, trench collapses, dam failures, foundation due to earthquakes, erosion, deterioration, tree roots, groundwater and moisture problems, groundwater problems, retaining failures problems, pavement failures and issues, failures in soil reinforcement and geosynthetics, development of codal provisions and performance based analysis procedures.

Sivakumar Babu G L

Bolton M (1991) A Guide to Soil Mechanics,Universities Press,Robert W. Day (2011) Forensic Geotechnical and Foundation Engineering,Second Edition,McGraw-Hill Companies

CE 270 (AUG) 3:0

Travel Demand Modeling

Individual travel behavior and aggregate-level travel demand analysis; Alternative approaches to modeling travel demand (aggregate, trip-based approaches and disaggregate, activity-based approaches); Econometric methods for modeling travel demand (development, estimation, and application of statistical models for travel behavior analysis); Linear regression for activity and trip generation (specification, interpretation, estimation, hypothesis testing, market segmentation, non-linear specification, tests on assumptions); Mode choice and destination choice using discrete choice methods (introduction to binary logit and multinomial logit models, contrast with gravity methods); Traffic assignment/route choice (network equilibrium, system optimum); Model transferability; Microsimulation for activity-based models; Recent advances.

Abdul Rawoof Pinjari

J. de D. Ortuzar and L.G. Willumsen. Modelling Transport (4th edition). John Wiley and Sons. 2011.,F. Koppelman and C.R. Bhat. A Self-Instructing Course in Mode Choice Modeling: Multinomial and Nested Logit Models

CE 273 (AUG) 3:0

Markov Decision Processes

Tarun Rambha

Puterman, M. L. (2014). Markov decision processes: discrete stochastic dynamic programming. John Wiley & Sons.~Bertsekas, D. P. (1995). Dynamic programming and optimal control (Vol. 1, No. 2). Belmont, MA: Athena scientific.~Kulkarni, V. G. (2016). Modeling and analysis of stochastic systems. CRC Press.

CE 269 (AUG) 3:0

Traffic Engineering

Tarun Rambha

Roess, R.P., Prassas E.S. & McShane, W.R. (2010), Traffic Engineering, Prentice Hall, USA.~May, A. D. (1990), Traffic Flow Fundamentals, Prentice Hall, USA.~Highway Capacity Manual (2010), Transportation Research Board, USA.~Kadiyali, L. R. (2000), Traffic Engineering and Transport Planning, Khanna Publishers, India.~Salter, R J. & Hounsell, N. B. (1996), Highway Traffic Analysis and Design, Macmillan Education, UK.

CE 234 (AUG) 3:0

Nonlinear Analysis in Earthquake Engineering

Earthquake load specification via time histories and response spectra. Seismic hazard. Spectrum compatible accelerograms. Numerical integration of equations of motion. Geometric and material nonlinear behaviour. Characterization of hysteresis, strength and stiffness degradations, pinching, and residual deformations. Oscillator models for inelastic behaviour. Internal variables. Energy dissipation characteristics. Models for seismic demands and capacities. Inelastic response spectrum. Ductility demand and yield capacity. P- ? effects. Global damage indices. Oscillator and FE based models for buildings and bridges under earthquake loads. Vibration isolation. Soil-structure interactions. Seismic collapse capacity using nonlinear static and incremental dynamic analyses. Capacity spectrum. Seismic fragility and vulnerability analyses. Performance based earthquake
engineering formats.

Manohar C S

Chopra, A K, 1996, Dynamics of structures, Prentice Hall, New Dehli.~Villaverde, R, 2009, Fundamental concepts of earthquake engineering, CRC Press, Boca Raton.~Elnashai A S, and L D Sarno, 2008, Fundamentals of earthquake engineering, Wiley, Chichester.~Current Literature

CE 244 (AUG) 3:0

Monte Carlo simulations in structural mechanics

Pseudo-random number generators; Tests for randomness; Generation of scalar and vector random variables; Transformation techniques; Accept-reject method; Markov Chain Monte Carlo; Simulation of scalar and vector random processes; Fourier series representations; Karhunen-Loeve expansions; filtered white noise models and SDE-s; treatment of nonstationarity and non-Gaussianity; Applications to structural reliability estimation; Variance reduction techniques; Subset simulations; Simulation of randomly vibrating systems; Discretization of SDE-s; Girsanov transformation; Sequential Monte Carlo and applications in state estimation and system identification; Conditional simulations.

Manohar C S

Liu, J S, 2001, Monte Carlo strategies in scientific computing, Springer, New York~Kloeden P E and E Platen, 1992, Numerical solution of stochastic differential equations, Springer-Verlag, Berlin.~Springer-Verlag, Berlin. Kroese, D P, T Taimre, and Z I Botev, 201,, Handbook of Monte Carlo methods, Wiley, New Jersey.~Current Literature

CE 205 (AUG) 3:0

Finite Element Method

Chandra Kishen J M

CE 204 (AUG) 3:0

Solid Mechanics

Introduction to tensor algebra and calculus, indicial notation, matrices of tensor components, change of basis formulae, eigenvalues, Divergence theorem. Elementary measures of strain. Lagrangian and Eulerian description of deformation. Deformation gradient, Polar decomposition theorem, Cauchy-Green and Lagrangian strain tensors. Deformation of lines, areas and volumes. Infinitesimal strains. Infinitesimal strain-displacement relations in cylindrical and spherical coordinates. Compatibility. Tractions, body forces, stress at a point, Cauchy's theorem. Piola-Kirchhoff stress tensors. Momentum balance. Symmetry of the Cauchy stress tensor. St. Venant's Principle. Virtual Work. Green's solids, elastic strain energy, generalized Hooke's Law, material symmetry, isotropic linear elasticity in Cartesian, cylindrical and spherical coordinates, elastic moduli, plane stress, plane strain,. Navier's formulation. Airy stress functions. Selected problems in elasticity. Kirchhoff's uniqueness theorem, Betti-Maxwell reciprocal theorem, Principle of stationary potential energy, Torsion in circular and non-circular shafts and thin-walled tubes, warping. Pure bending of thin rectangular and circular plates, small deflection problems in laterally loaded thin rectangular and circular plates. Outline of Mindlin plate theory.

Narayan K Sundaram

Fung Y. C. and Pin Tong, Classical and Computational Solid Mechanics, World Scientific, 2001~Boresi, A.P., Chong K., and Lee J., Elasticity in Engineering Mechanics, Wiley, 2010~Theoretical Elasticity, A.E. Green and W. Zerna, 1968, Dover Publications~Malvern L., Introduction to the Mechanics of a Continuous Medium, Prentice Hall, 1969

CE 230 (AUG) 3:0

Pavement Engineering

Introduction to pavement engineering: Design of flexible and rigid pavements; selection of pavement design input parameters, traffic loading and volume, material characterization, drainage, failure criteria: pavement design of overlays and drainage system: pavement performance evaluation: non-destructive tests for pavement: IRC, AASHTO design codes: maintenance and rehabilitation of pavement

Sivakumar Babu G L

Rajib B Mallick and Tahar El-Korchi,Pavement Engineering,Principles and Practice,CRC Press,2009

CE 262 (JAN) 3:0

Public Transportation Systems Planning

Modes of public transportation and application of each to urban travel needs; comparison of transit modes and selection of technology for transit service; transit planning, estimating demand in transit planning studies, demand modeling, development of generalized cost, RP & SP data and analysis techniques; functional design and costing of transit routes, models for planning of transit routes, scheduling; management and operations of transit systems; integrated public transport planning; operational, institutional, and physical integration; models for integrated planning; case studies.

Ashish Verma

A. Verma and T. V. Ramanayya, Public Transport Planning and Management in Developing Countries, CRC Press, 2014,VuchicVukan R., Urban Transit: Operations, Planning and Economics, Prentice Hall, 2005.,Gray G. E., and Hoel L. A., Public Transportation, Prentice Hall, 1992.

CE 230 (JAN) 3:0

Pavement Engineering

Introduction to pavement engineering: Design of flexible and rigid pavements; selection of pavement design input parameters, traffic loading and volume, material characterization, drainage, failure criteria: pavement design of overlays and drainage system: pavement performance evaluation: non-destructive tests for pavement: IRC, AASHTO design codes: maintenance and rehabilitation of pavements

Rajib B Mallick and Tahar El-Korchi, Pavement Engineering, Principles and Practice, CRC Press, 2009,Huang, Y.H, Pavement Analysis and Design, Prentice-Hall, New Jersey, 1993.,E. J. Yoder, M. W. Witczak, Principles of Pavement Design, Wiley New York, 1975

CE 248 (JAN) 3:0

Regionalization in Hydrology and Water Resources Engineering

Prediction in ungauged basins. Regional frequency analysis- probability weighted moments and its variations, stationary and non-stationary distributions, regional goodness-of-fit test. Approaches to regionalization of hydro-meteorological variables and extreme events. Regional homogeneity tests. Prediction of hydro-meteorological variables in gauged and ungauged basins, Estimation of probable maximum precipitation and probable maximum flood, and their use in hydrologic design.

Srinivas V V

Prerequisite : CE 203 Diekkrüger,B.,Schröder,U.,Kirkby

CE 225 (JAN) 3:0

Engineering Rock Mechanics

Rock as an engineering material, Geological factors affecting rocks, Stress, Strain and Strength of rocks, Insitu stresses in rock, Intact Rock - Elastic Deformation, Discontinuities and deformability and strength of rock masses, permeability, anisotropy and in homogeneity in rocks, Stereonet Analysis, testing techniques, rock mass classification, Failure criteria for rock and rock masses, Rock mechanics interactions and rock engineering systems, Excavation and stabilization principles, rock slope stability, foundations on rock, rock blasting support and reinforcement, Underground excavation and stability, Urban tunnels, Problematic Rocks - Rock Engineering, Modern modelling techniques & analyses in rocks.

Sitharam G Thallak

Hudson J.A. and J.P. Harrison. Engineering Rock Mechanics: an Introduction to the Principles,1997. Elsevier,Oxford,Goodman,R.E. Introduction to Rock Mechanics

CE 235 (JAN) 3:0

Optimization Methods

Basic concepts, Kuhn-Tucker conditions, linear and nonlinear programming, treatment of discrete variables, stochastic programming, Genetic algorithm, simulated annealing, Ant Colony and Particle Swarm Optimization, Evolutionary algorithms, Applications to various engineering problems.

Ananth Ramaswamy

Arora,J.S. Introduction to Optimization,McGraw-Hill (Int. edition)1989.,Rao,S.S.

CE 213 (JAN) 3:0

Systems Techniques in Water Resources Engineering

Optimization Techniques - constrained and unconstrained optimization, Kuhn-Tucker conditions, Linear Programming (LP), Dynamic Programming (DP), Multi-objective optimization, applications in water resources, water allocation, reservoir sizing, multipurpose reservoir operation for hydropower, flood control and irrigation. Review of probability theory, stochastic optimization. Chance constrained LP, stochastic DP. Surface water quality control. Simulation - reliability, resiliency and vulnerability of water resources systems.

Nagesh Kumar D

Loucks, D.P., Stedinger, J.R. and Haith, D.A., Water Resources Systems Planning and Analysis, Prentice Hall, Englewood Cliffs, N.J, 1981.,Vedula, S. and Mujumdar, P. P., Water Resources Systems: Modelling Techniques Tata-McGraw Hill, 2005.,Srinivasa Raju, K and Nagesh Kumar, D., Multicriterion Analysis in Engineering and Management, PHI Ltd., New Delhi, 2010.~D.P.~Stedinger~J.R. and Haith~D.A.

CE 222 (JAN) 3:0

Fundamentals of Soil Behaviour

Identification and classification of clay minerals, expansive and collapsing soils; Concepts and measurements of matric and osmotic suction, Role of inter-particle forces and suction in effective stress, Role of clay mineralogy, inter-particle forces and suction in volume change, hydraulic conductivity and shear strength of soils

Sudhakar Rao M, Raghuveer Rao P

Mitchell,J. K. Fundamentals of Soil Behaviour,Wiley,2005.,Yong

CE 206 (JAN) 3:0

Earth and Earth Retaining Structures

Lateral earth pressure coefficients, Rankine and Coulomb theories. Graphical constructions, passive earth pressure with curved rupture surfaces, arching, stability of retaining walls, stability of vertical cuts. Braced excavations, anchored sheet piles, stability of infinite slopes, stability of finite slopes. Methods of slices - Swedish, Morgenstern and Price methods. Stability analysis of earth and rock-fill dams.

Jyant Kumar

Terzaghi, K., Theoretical Soil Mechanics, John Wiley, 1965.,Taylor, D.W., Fundamentals of Soil Mechanics, John Wiley, 1948.,Bowles, J.W., Analysis and Design of Foundations, 4th and 5th Ed., McGraw-Hill, 1988 & 1996.,Lambe, T.W. and Whitman, R.V., Soil Mechanics, Wiley Eastern Limited, 1976.~K.~Theoretical Soil Mechanics~John Wiley~1965.

CE 209 (JAN) 3:0

Mechanics of Structural Concrete

Introduction, Limit state design philosophy of reinforced concrete, Stress-strain behavior in multi-axial loading, failure theories, plasticity and fracture, ductility, deflections, creep and shrinkage, Strength of RC elements in axial, flexure, shear and torsion, RC columns under axial and eccentric loading, Beam-column joints, Strut and Tie modelling, Yield line theory of slabs, Seismic resistant design, Methods for predicting the behavior of pre-stressed concrete members and structures.

Chandra Kishen J M

Nilson,A. H.,Darwin,D. and Dolan,C. W.

CE 215 (JAN) 3:0

Stochastic Hydrology

Introduction to random variables, statistical properties of random variables. Commonly used probability distributions in hydrology. Fitting probability distributions to hydrologic data. Probability plotting and frequency analysis. Data generation. Modeling of hydrologic uncertainty - purely stochastic models, first order Markov processes. Analysis of hydrologic time series - auto correlation and spectral density functions. Applications to hydrologic forecasting.

Mujumdar P P

Bras, R.L. and Rodriguez-Iturbe, Random Functions and Hydrology, Dover Publications, New York, USA, 1993.,Hann, C.T., Statistical Methods in Hydrology, First East-West Press Edition, New Delhi, 1995.,Ang, A.H.S. and Tang, W.H.,Probabilistic concepts in Engineering Planning Design, Vol. 1, Wiley, New York, 1975.,Clarke, R.T., Statistical Models in Hydrology, John Wiley, Chinchester, 1994

CE 267 (JAN) 3:0

Transportation Statistics and Micro-simulation

Role of statistics in transportation engineering; graphical methods for displaying transportation data; numerical summary measures; random variables in transportation; common probability distributions in transportation; use of sampling and hypothesis testing in transportation; use of ANOVA; regression models for transportation; Bayesian approaches to transportation data analysis; traffic micro-simulation models, analysing micro-simulation outputs, performance measures.

Ashish Verma

Spiegelman,C.H., Park, E.S. and Rilett, L.R. Transportation Statistics and Microsimulation, CRC Press, 2011.,Benjamin J.R. and Cornell, C. A. Probability, Statistics, and Decisions for Civil Engineers, McGraw-Hill Book Company, 1970,-

CE 214 (JAN) 3:0

Ground Water Hydrology

Ground water and hydrological cycle. Ground water movement and balance. Ground water monitoring. Equations of flow. Well hydraulics - analysis of aquifer tests and models. Regional groundwater resource evaluation and numerical modeling. Groundwater recharge estimation. Base flow analysis and models. Ground water quality. Mass transport in ground water. Tracer tests and scale effects of dispersion. Solute transport modeling.

Sekhar M

Freeze,A. R. And Cherry,J. A. Groundwater,Prentice Hall,1979.

CE 208 (JAN) 3:0

Ground Improvement and Geosynthetics

Principles of ground improvement, mechanical modification. Properties of compacted soil. Hydraulic modification, dewatering systems, preloading and vertical drains, electro-kinetic dewatering, chemical modification, modification by admixtures, stabilization using industrial wastes, grouting, soil reinforcement principles, properties of geo-synthetics, applications of geo-synthetics in bearing capacity improvement, slope stability, retaining walls, embankments on soft soil, and pavements, filtration, drainage and seepage control with geo-synthetics, geo-synthetics in landfills, soil nailing and other applications of geo-synthetics.

Sivakumar Babu G L

Hausmann, M.R., Engineering Principles of Ground Modification, McGraw-Hill, 1990.,Jones, C.J.E.P., Reinforcement and Soil Structures, Butterworth Publications, 1996.,Koerner, R. M., Designing with Geosynthetics, Prentice Hall Inc. 1998.

CE 207 (JAN) 3:0

Geo-environmental Engineering

Sources, production and classification of wastes, Environmental laws and regulations, physico-chemical properties of soil, ground water flow and contaminant transport, contaminated site characterization, estimation of landfill quantities, landfill site location, design of various landfill components such as liners, covers, leachate collection and removal, gas generation and management, ground water monitoring, end uses of landfill sites, slurry walls and barrier systems, design and construction, stability, compatibility and performance, remediation technologies, stabilization of contaminated soils and risk assessment approaches.

Sivakumar Babu G L

Sharma,H.D.,and Reddy,K.R.,Geoenvironmental Engineering: Site Remediation

CE 212 (JAN) 3:0

Computational Fluid Dynamics in Water Resources Engineering

Governing equations of fluid dynamics, numerical solution of ODEs, Classification of Quasi-Linear PDEs, classification of PDEs, Solution methods for Parabolic, Elliptic and Hyperbolic PDEs and their analysis. Curvilinear co-ordinates and grid generation. Introduction to finite difference, finite volume and finite elements method, Application of CFD to open channel flow, pipe flow, porous media and contaminant transport problems.

Mohan Kumar M S

Computational Fluid Dynamics: Applications in Environmental Hydraulics,edited by Paul D. Bates,Stuart N. Lane,Robert I. Ferguson,Wiley; 1st edition

CE 238 (JAN) 3:0

Structural Masonry

Masonry materials, Masonry characteristics, Compression failure theories, masonry in tension, shear and biaxial stress, laterally loaded un-reinforced walls, Strength of masonry arches, Design of reinforced and un-reinforced masonry structures.

Venkatarama Reddy B V

Hendry,A. W.,Structural Masonry,MacMillan Press,1998 Current literature

CE 210 (JAN) 3:0

Structural Dynamics

Equations of motion. Degrees of freedom. D' Alembert principle. SDOF approximation to vibrating systems. Energy storage elements: mass, stiffness and damper. Undamped free vibration. Natural frequency. Damped free vibration. Critical damping. Forced response under periodic and aperiodic excitations. Support motions. Resonance. Impulse response and complex frequency response functions. Duhamel integral. Vibration isolation: FTR and DTR. Multi-DOF systems. Normal modes and natural frequencies. Orthogonality of normal modes. Natural coordinates. Uncoupling of equations of motion. Repeated natural frequencies. Proportional and non proportional damping. Damped normal modes. Principle of vibration absorber. Continuous systems. Vibration of beams. Forced response analysis by eigenfunction expansion. Moving loads and support motions. Effect of axial loads. Approximate methods for vibration analysis. Rayleigh's quotient. Rayleigh-Ritz method. Method of weighted residual. Method of collocation. Galerkin's method.

Manohar C S

Meirovich, L., 1984, Elements of vibration analysis, McGraw-Hill, NY,Clough R W and J Penzien, 1993, Dynamics of structures, McGraw-Hill, NY,Rao,S S 2004, Mechanical Vibrations, 4th Edition, Pearson Education, New Delhi.

CE 228 (JAN) 3:0

Introduction to the Theory of Plasticity

1D plasticity and visco-plasticity; physical basis of plasticity; uniaxial tensile test & Bauschinger effect; structure of phenomenological plasticity theories; internal variables; yield criteria (Tresca, von Mises, Mohr-Coulomb, Drucker-Prager); geometry of yield surfaces; Levy-Mises equations; flow rules; plastic/ viscoplastic potentials; consistency condition; isotropic and kinematic hardening; Drucker's postulate; Principle of maximum plastic dissipation; associativity; convexity; normality; uniqueness; selected elastic-plastic boundary value problems (tension and torsion of tubes and rods, pressurized thin and thick spherical shells); collapse; advanced hardening models; introduction to computational plasticity; integration of plasticity models; return mapping; principle of virtual work; Finite elements for plasticity

Ananth Ramaswamy

Chakrabarty, J. Theory of Plasticity, Butterworth, 2006,Calladine, C.R., Plasticity for Engineers, Woodhead, 2000,Lubliner J., Plasticity Theory, Dover, 2008

CE 227 (JAN) 3:0

Engineering Seismology

Introduction to earthquake hazards. Strong ground motions, tsunamis, landslides, liquefaction. Overview of plate tectonics and earthquake source mechanisms. Theory of wave propagation. Body waves and surface waves. Concepts of seismic magnitudes and intensity. Seismic station. Sensors and data loggers, mechanical and digital sensors. Interpretation of seismic records – acceleration, velocity and displacement. Regional seismicity and earthquakes in India. Seismic zonation – scales, macro and micro, attenuation, recurrence relation. Seismic hazard analysis - deterministic and probabilistic. Site characterization – different methods and experiments. Local site effects, ground motion amplifications. Development of response/design spectrum. Liquefaction hazard assessments. Integration of hazards using GIS. risk and vulnerability Studies.

Anbazhagan P

Earthquake Engineering – From Engineering Seismology to Performance Based Engineering,Edited by Bozorgnia,Y. and Bertero,V.V.,CRC Press Washington 2004.

CE 239 (JAN) 3:0

Stochastic Structural Dynamics

Introduction to random variables and processes: probability, random variables. Transformations of random variables. Stationary, ergodic and non-stationary stochastic processes. Linear transformation of stationary-ergodic stochastic processes. Normal Gaussian Stochastic processes. PSD functions. Wiener processes and an introduction to Ito calculus. Response of SDOF and MDOF oscillators under random inputs. Oscillators subject to white noise excitations. Input-output relations in time and frequency domains under the assumption of response stationarity. Handling non-stationarity in the response. level crossing and first passage problems. Nonlinear oscillators under random inputs: sources of non-linearity. Equivalent linearization and perturbation methods. Numerical integration and Monte Carlo simulations: Ito-Taylor expansions. Stochastic Euler and Heun methods. Higher order implicit and explicit methods. Errors in Monte-Carlo simulations. Variance reduction techniques.

Debasish Roy

Lin,Y K,Probabilistic Structural Dynamics,McGraw-Hill,Kloeden

CE 271 (JAN) 3:0

Choice Modeling for Transportation Planning

Individual choice theories; Binary choice models; Unordered multinomial choice models (multinomial logit and multinomial probit); Ordered response models (ordered logit, ordered probit, generalized ordered response; rank-ordered data models); Maximum likelihood estimation; Sampling based estimation (choice-based samples and sampling of alternatives); Multivariate extreme value models (nested logit, cross-nested logit); Mixture models (mixed logit and latent class models); Mixed multinomial probit; Integrated choice and latent variable models; Discrete-continuous choice models with corner solutions; Alternative estimation methods (EM, analytic approximations, simulation); Applications to travel demand analysis.

Abdul Rawoof Pinjari

Prerequisites: Travel Demand Modeling F. Koppelman & C.R. Bhat. A Self-Instructing Course in Mode Choice Modeling: Multinomial and Nested Logit Models,2006.,K. Train. Discrete Choice Methods with Simulation (2nd edition),Cambridge University Press,2009.

CE 232 (JAN) 3:0

Geotechnical Engineering and Rehabilitation of Dams

Geotechnical and geological aspects of the investigations for dams. Phases of geotechnical investigations. Review and assessment of existing dams in India and History of dams. Design and construction of embankment dams including their zoning and selection of type of dams. Shear strength, compressibility and permeability of embankment materials and soil foundations. Design methods with the theoretical basis. Design, specifications and construction of filters. Foundation preparation and grouting. Seepage analyses and control. Stability analyses and deformation with and without earthquakes. Internal erosion and piping. Embankment dam details like freeboard slope protection, crest details, dimensioning and tolerances. Construction methods. Flood control structures and conduits/pipes through dams. Rockfill dams. Mine and Industrial Tailing dams. Ground motions and soil liquefaction during earthquakes. Geosynthetics in earth dams. Monitoring and surveillance of earth dams. Assessment, safety and management of dams. Dam rehabilitation plans. Foundations for gravity dams and Geotechnical engineering aspects for concrete gravity and arch dams.

Sitharam G Thallak

Robin Fell, Patrick MacGregor, David Stapledon and Graeme Bell, (2005) Geotechnical Engineering of dams, 2nd Edition, Taylor and Francis Group, London, UK,Sherard J L., Woodward, R J., Gizienski, S F., and Clevenger W.A. (1963) Earth and rockfill dams, John Wiley & Sons.,International Committee on Large dams (ICOLD) reports and manuscripts

CE 272 (JAN) 3:0

Traffic Network Equilibrium

Traffic assignment; Fixed points and Variational inequalities; Fundamentals of convex optimization; Shortest path algorithms; Wardrop user equilibrium; System optimum and Price of Anarchy; Link-based algorithms (Method of successive averages, Frank-Wolfe); Potential games; Variants of the traffic assignment problem (Multiple-classes, Elastic demand); Path-based algorithms; Origin-based methods; Sensitivity analysis.

Tarun Rambha

Sheffi, Y. Urban Transportation Networks: Equilibrium Analysis with Mathematical Programming Methods. Prentice Hall, 1985.,Patriksson, M. The traffic assignment problem: models and methods. Courier Dover Publications, 2015.

CE 240 (JAN) 3:0

Uncertainty Modeling and Analysis

Deterministic vs nondeterministic perspectives. Sources of uncertainty. Epistemic vs. aleatoric uncertainty. Data driven vs. physics driven uncertainty modelling. Different approaches such as probabilistic, interval, fuzzy. Introductory probability and statistics, point estimation, hypothesis testing, time series. Modelling: connecting data to the probabilistic models. Discretization of random fields. Tools for uncertainty propagation. Computational aspects of uncertainty propagation.

Debraj Ghosh

Prerequisite: Basic knowledge of probability~Applied Statistics and Probability for Engineers by Douglas C. Montgomery & George C. Runger, John Wiley and Sons, 2010~Current literature

CE 299 (JAN) 0:22

Project

CE 206 (JAN) 3:0

Earth and Earth Retaining Structures

Lateral earth pressure coefficients, Rankine and Coulomb theories. Graphical constructions, passive earth pressure with curved rupture surfaces, arching, stability of retaining walls, stability of vertical cuts. Braced excavations, anchored sheet piles, stability of infinite slopes, stability of finite slopes. Methods of slices - Swedish, Morgenstern and Price methods. Stability analysis of earth and rock-fill dams.

Jyant Kumar

Terzaghi~K.~Theoretical Soil Mechanics~John Wiley~1965.

CE 215 (JAN) 3:0

Stochastic Hydrology

Introduction to random variables, statistical properties of random variables. Commonly used probability distributions in hydrology. Fitting probability distributions to hydrologic data. Probability plotting and frequency analysis. Data generation. Modeling of hydrologic uncertainty - purely stochastic models, first order Markov processes. Analysis of hydrologic time series - auto correlation and spectral density functions. Applications to hydrologic forecasting.

Mujumdar P P

Bras~R.L. and Rodriguez-Iturbe~Random Functions and Hydrology~Dover Publications~New York

CE 208 (JAN) 3:0

Ground Improvement and Geosynthetics

Principles of ground improvement, mechanical modification. Properties of compacted soil. Hydraulic modification, dewatering systems, preloading and vertical drains, electro-kinetic dewatering, chemical modification, modification by admixtures, stabilization using industrial wastes, grouting, soil reinforcement principles, properties of geo-synthetics, applications of geo-synthetics in bearing capacity improvement, slope stability, retaining walls, embankments on soft soil, and pavements, filtration, drainage and seepage control with geo-synthetics, geo-synthetics in landfills, soil nailing and other applications of geo-synthetics.

Gali Madhavi Latha

Hausmann, M.R., Engineering Principles of Ground Modification, McGraw-Hill, 1990.~Jones, C.J.E.P., Reinforcement and Soil Structures, Butterworth Publications, 1996.~Koerner, R. M., Designing with Geosynthetics, Prentice Hall Inc. 1998.

Dept of Chemical Engineering

Coursesin the Department

August Semester			January Semester		
CH 201	3:0	Engineering Mathematics	CH205	3:0	Chemical Reaction Engineering
CH 202	3:0	Numerical Methods	CH 207	1:0	Applied Statistics & design of Experiments
CH 203	3:0	Transport Phenomena	CH 232	3:0	Physics of Fluids
CH 204	3:0	Thermodynamics	CH 234	3:0	Rheology of Complex Fluids
CH 206	1:0	Seminar	CH 236	3:0	Statistical Thermodynamics
CH 235	3:0	Modelling in Chemical Engineering	CH 243	3:0	Mechanics of Particle Suspensions
CH 242	3:0	Special Topics in Theoretical Biology	CH 245	3:0	Interfacial and Colloidal Phenomena
CH 244	3:0	Treatment of Drinking Water	CH 247	3:0	Introduction to Molecular Simulations
CH 248	3:0	Molecular Systems Biology	CH 249	3:0	Structural and Functional Nanotechnology
CH 299	0:32	Dissertation Project (M Tech)			

The detailed contentof the active courses in a given academic year is appended below. Please note that all the courses listed above are not active every year.

The table below shows the department requirements for its various programmes.

Programme	Credits	DepartmentRequirements
M Tech Programme, duration 2 years	64	Course work of 32 creditsincludes a core of 17 credits (CH 201 to CH 207), and a soft core of 6 credits from the department offerings.The project work is equivalent of 32 credits.
M Tech (Res) Programme	12	CH 201 or CH 202, anda minimum of two from CH 203, CH 204, and CH 205. CH 206 and CH 207 are compulsory. A maximum of 21 credits is permitted.
PhD Programme, after Bachelor's degree	24	Aminimum of four from CH 201, 202, 203, 204, and 205. CH 206 and CH 207 are compulsory. A maximum of 33 credits is permitted.
PhD Programme, after Master's degree	12	CH 201 or CH 202, and a minimum of two from CH 203, 204, and 205. CH 207 is compulsory. A maximum of 21 credits is permitted.

CH 202 (AUG) 3:0
Numerical Methods

Basics of scientific computing, basics of Matlab programming, solutions of linear algebraic equations, eigenvalues and eigenvectors of matrices, solutions of nonlinear algebraic equations, Newton-Raphson methods, function approximation, interpolation, numerical differentiation and integration, solutions of ordinary differential equations – initial and boundary value problems, solutions of partial differential equations, finite difference methods, orthogonal collocation.

Bhushan J Toley

Gupta S.K., Numerical Methods for Engineers, New Age International Publishers, 3rd edition, 2015,Chapra, S.C. and Canale, R.P., Numerical Methods for Engineers, McGraw Hill, NY, 6th edition, 2010,Beers, K.J., Numerical Methods for Chemical Engineering, Cambridge Univ. Press, Cambridge, UK 2010

CH 244 (AUG) 3:0

Treatment of Drinking Water

Availability of water, contaminants and their effects on human health, quality standards. Removal of contaminants by various processes: chlorination, filtration, coagulation and flocculation, reverse osmosis, adsorption and ion exchange. Rainwater harvesting

Kesava Rao K

Droste, R.L., Theory and Practice of Water and Wastewater Treatment, Wiley (Asia), 2004,Sawyer, C.N., McCarty, P.L., and Parkin, G.F., Chemistry for Environmental Engineering and Science, Fifth Edn, Tata McGraw Hill, 2004.,Lecture notes.

CH 203 (AUG) 3:0

Transport Processes

Dimensional analysis and empirical correlations. Molecular origins of diffusion. Steady/unsteady shell balances in one/two dimensions. Solution of unsteady diffusion equation by similarity transform and separation of variables. Conservation laws and constitutive relations in three dimensions. Diffusion dominated transport. Fluid flow due to pressure gradients. Boundary layer theory for transport in forced convection. Natural convection. References:

Kumaran V

Bird, R.B, Stewart, W.E. and Lightfoot, E.N., Transport Phenomena, Wiley, 1994.,L. G. Leal, Luminar Flow and Convective Transport Processes, Butterworth Heineman, 1992.

CH 201 (AUG) 3:0

Engineering Mathematics

Linear algebraic equations, linear operators, vector and function spaces, metric and normed spaces, existence and uniqueness of solutions. Eigen values and eigen vectors/functions. Similarity transformations, Jordan forms, application to linear ODEs, Sturm-Liouville problems. PDE's and their classification, initial and boundary value problems, separation of variables, similarity solutions. Series solutions of linear ODEs. Elemetary perturbation theory. References:

Prabhu R Nott

Linear Algebra and its Applications,Gilbert Strang,Thompson (Indian edition).,Mathematical Methods for Physicists,J. B. Arfken and H. J. Weber

CH 242 (AUG) 3:0

Special Topics in Theoretical Biology

Motivation for theoretical studies of biological phenomena; Population dynamics and epidemiology; Viral dynamics; Drug pharmacokinetics and therapy; Molecular evolution and phylogenetics; Complex reaction networks; Immune responses; Cancer

Narendra M Dixit

1. J. D. Murray, Mathematical biology I & II, Springer, 2003 (3rd edition)~2. E. A. Allman and J. A. Rhodes, Mathematical models in biology: an introduction, Cambridge, 2004~3. M. A. Nowak and R. M. May, Virus dynamics: mathematical foundations of immunology and virology, Oxford, 2000~4. R. D. M. Page and E. C. Holmes, Molecular evolution: a phylogenetic approach, Wiley Blackwell, 1998~5. Recent journal articles, which will be handed out from time to time

CH 244 (AUG) 3:0

Treatment of drinking water

Availability of water; contaminants and their effects on human health; quality standards; removal of contaminants by various processes: chlorination, filtration, coagulation and flocculation, reverse osmosis, adsorption and ion exchange; rainwater harvesting; Sodis

Kesava Rao K

Droste, R. L., Theory and Practice of Water and Wastewater Treament, Wiley (Asia) 2004,World Health Organization, Guidelines for Drinking-water Quality, 4th ed., 2011,Current Literature

CH 206 (AUG) 1:0

Seminar Course

Sudeep Punnathanam

CH 207 (JAN) 1:0

Applied Statistics and Design of Experiments

Introduction to probability and statistics; conditional probability; independence; discrete and continuous random variables and distributions; sampling distributions; confidence interval; application of parameter estimation and hypothesis testing: statistical inference for one sample and two samples; application of parameter estimation and hypothesis testing; statistical inference for two samples; analysis of variance; linear and non-linear regression; design of experiments; factorial experiments

Kesava Rao K

Montgomery,D.C. and Runger,G.C.,Applied Statistics and Probability for Engineers,5th ed.

CH 205 (JAN) 3:0

Chemical Reaction Engineering

Overview of Chemical Reaction Engineering, The Attainable Region theory, Analysis of Multiple Reactions and Design of Ideal Reactors, Non-Ideal Reactor Analysis, Thermodynamics and Kinetics of Reactions, Concepts in Catalysis, Multiphase Reactor Design, CFD for Reactive

Venugopal S

Ming,D.,Glasser,D.,Hildebrandt

CH 234 (JAN) 3:0

Rheology of Complex Fluids and Particulate Materials

Introduction to complex fluids: Polymeric fluids, Suspensions, Pastes, soft glassy materials; Dry granular materials; Flow phenomena in complex fluids: Shear thinning and thickening, Shear bands, Creep; Introduction to principles of rheology; Kinematics: Viscometric flows; Material functions: Rheometry in simple flows; Rheological models: Generalized Newtonian fluid, Models for viscoelasticity, Models for plasticity and viscoplasticity; Applications to simple flow problems.

Prabhu R Nott

Larson, R., The Structure and Rheology of Complex Fluids, Oxford, 1999,Bird, R. B., Armstrong, R. C. and Hassager, O., Dynamics of Polymeric Liquids - Vol.1 Fluid Mechanics, Wiley, 1987,Rao, K. K. and Nott, P. R., An Introduction to Granular Flow, Cambridge, 2008.

CH 245 (JAN) 3:0

Interfacial and Colloidal Phenomena

Interfaces, Young-Laplace and Kelvin equations for curved interfaces; interfacial tension and contact angle, measurement techniques; wetting and spreading; colloids: Intermolecular forces, London-van der Waals attraction, double layer repulsion, zeta potential, DLVO theory of colloidal stability; non-DLVO forces; surfactants; thermodynamics of self-assembly, phase diagrams; electro-kinetic phenomena; electrochemical systems

Berg,J. C. An Introduction to Interfaces and colloids, The bridge to nanoscience, World Scientific, 2010.,. Israelachvili, J., Intermolecular and Surface Forces, Academic, Press, 3rd edition, 2011.,Hunter, R. J., Foundations of Colloid Science, Vol. I, II Oxford, University Press, 1986,Lecture notes given by instructor.

CH 299 (JAN) 0:32

Dissertation Project

The ME project is aimed at training the students to analyze independently any problem posed to them. The project may theoretical, experimental, or a combination. In few cases, the project may also involve sophisticated design work. The project report is expected to show clarity of thought and expression, critical appreciation of the existing literature, and analytical, experimental or design skills.

CH 248 (JAN) 3:0

Molecular Systems Biology

Various topics highlighting experimental techniques and modeling approaches in systems biology for problems ranging from molecular level to the multi-cellular level will be covered. Topics: Properties of biomolecules, Biomolecular Forces, Single molecule experimental techniques, Molecular motors, Molecular heterogeneity, Self-organization, Enzyme kinetics, Modeling cellular reactions and processes, Fluctuations and noise in biology, Cellular variability, Biological networks, Modeling dynamics of bioprocesses and cellular signaling

Rahul Roy

Philip Nelson, Biological Physics: Energy, Information, Life, W. H. Freeman, 2007,Edda Klipp, Wolfram Liebermeister, Christoph Wierling, Axel Kowald, Hans Lehrach, Ralf Herwig, 3. Systems Biology, Wiley-Vch, 2009,Uri Alon, An Introduction to Systems Biology: Design Principles of Biological Circuits, Chapman & Hall/CRC Mathematical & Computational Biology, 2006

CH 207 (JAN) 1:0

Applied statistics and design of experiments

Overview of statistics; introduction to probability and conditional probability; independence; discrete and continuous random variables and distributions; point estimation and sampling distributions; confidence interval; hypothesis testing for a single sample; statistical inference for two samples; linear regression and correlation; design and analysis for single-factor experiments; design of experiments with several factors

Kesava Rao K

Montgomery, D.C. and Runger, R.C., Applied Statistics and Probability for Engineers, Wiley (2014).,Montgomery, D.C., Design and Analysis of Experiments, Wiley 2013.,Hines, W.W., Montgomery, D.C., Goldsman, D.M., and Borror, C.M., Probability and Statistics in Engineering, Wiley, 2006

CH 236 (JAN) 3:0

Statistical Thermodynamics

Introduction to ensembles, partition functions, relation to thermodynamics; imperfect gases; density distribution functions; integral equations and perturbation theories of liquids; lattice gas; Ising magnets; Bragg Williams approximation; Flory Huggins theory; Molecular modeling of intermolecular forces

Sudeep Punnathanam

McQuarrie, D.A., Statistical Mechanics, Viva Books, 2003.,Hill, T. L., An Introduction to Statistical Thermodynamics, Dover Publications, 1986,Chandler, D, Introduction to Modern Statistical Mechanics, Oxford University Press, New York, 1986

Dept of Mechanical Engineering

M Tech Programme

Duration: 2 years
64 credits

Hard Core: 19 credits

ME 201	3:0	Fluid Mechanics
ME 228	3:0	Materials & Structure Property Correlations
ME 240	3:0	Dynamics & Control of Mechanical Systems
ME 242	3:0	Solid Mechanics
ME 271	3:0	Thermodynamics
ME 297	1:0	Seminar Course
ME 261	3:0	Engineering Mathematics
		OR
MA 211	3:0	Matrix Theory
		OR
MA 251	3:0	Numerical Methods
		OR
PH 205	3:0	Mathematical Methods of Physics

OR

Any other course recommended by the department

Project: 27 Credits
ME 299 0:27 Dissertation Project
Electives: The balance of 18 credits required to make up a minimum of 64 credits to complete the M.E. Program.

ME 225 (AUG) 1:0

Introduction to Soft Matter

Introductory course on soft matter/complex fluids. A review of preliminaries of continuum mechanics, which are required for dealing with soft matter. General concepts of viscous and elastic deformations and relevant models. Experimental approaches to soft materials such as creep response and stress relaxation.

Aloke Kumar

Bird, R.B., Armstrong, R.C., Hassager, O., Dynamics of Polymeric Fluids, John Wiley and Sons~Joseph, D.D, Fluid Dynamics of Viscoelastic Liquids, Spinger-Verlag, 1990~Gurtin,M.E., Fried, E., Anand, L.The Mechanics and Thermodynamics of Continua, Cambridge University Press 2011~R.C.~Hassager

ME 242 (AUG) 3:0

Solid Mechanics

Analysis of stress, analysis of strain, stress-strain relations, two-dimensional elasticity problems, airy stress functions in rectangular and polar coordinates, axisymmetric problems, energy methods, St. Venant torsion, elastic wave propagation, elastic instability and thermal stresses.

Ramsharan Rangarajan

Foundations of Solid Mechanics, Fung Y C~Srinath. L. S., Advanced Mechanics of Solids, Tata McGraw Hill.~Sokolnikoff, I. S., Mathematical Theory of Elasticity, Prentice Hall.

ME 271 (AUG) 3:0

Thermodynamics

Concepts of thermodynamics, zeroth law, first law, properties of pure substances and mixtures, first order phase transitions, thermophysical properties, energy storage; second law; energy analysis of process and cycle; calculation of entropy and entropy diagrams; availability analysis, chemical equilibrium, non-equillibrium thermodynamics, multi-phase-multi component systems, transport properties; third law

Susmita Dash

Van Wylen, G. J., and Sonntag, R.E., Fundamentals of Classical Thermodynamics, Willey~Moran, M. J., Shapiro, H. N. Fundamentals of Engineering Thermodynamics, Willey~Reynolds, W. C., Perkins, H. C., Engineering Thermodynamics

ME 230 (AUG) 3:0

Structural Stability and Fracture Control

Appreciation of structural integrity, Notions of stability in engineering, Static and dynamic stability analysis, Basics of engineering fracture mechanics, Concepts of stable and unstable fracture, Basics of engineering plasticity, Elements of structural control engineering.

Yogendra Simha K R

Graff K.F. (1975): Wave Motion in Elastic Solids (DOVER)~Simha K. R. Y. (2001): Fracture Mechanics for Modern Engineering Design, Universities Press~Timoshenko S.P. and Gere J.M. (1963): Theory of Elastic Stability, McGraw-Hill~C.Lakshmana Rao, V.Narayanamurthy and K R Y Simha (2016): Applied Impact Mechanics, John Wiley~D.W.A. Rees (2006) : Basic Engineering Plasticity, Elsevier

ME 294 (AUG) 3:0

Applied Impact Mechanics of Solids

Appreciation of Impact Problems in Engineering, Impact Plasticity, Fracture, Comminution and Concussion; Elements of Elasto-dynamics, Vibration and Waves; Characteristics of Bulk Pand- S Waves in infinite media; Characteristics of Rayleigh Surface Wave; Reflection, refraction and absorption of stress waves; Dispersion, nonlinearity,(acousto-elasticity), searching for solitons

Ratnesh K Shukla

Pre-requisite: ME 242 Solid Mechanics or Equivalent Timoshenko,S,P,and Goodier,J.N. Theory of Elasticity

ME 201 (AUG) 3:0

Fluid Mechanics

Fluid as a continuum, mechanics of viscosity, momentum and energy theorems and their applications, compressible flows, kinematics, vorticity, Kelvin's and Helmholtz's theorems, Euler's equation and integration, potential flows, Kutta-Joukowsky theorem, Navier-Stokes equations, boundary layer concept, introduction to turbulence, pipe flows.

Ratnesh K Shukla, Gaurav Tomar

Kundu,P.K.,and Cohen,I.M.,Fluid Mechanics

ME 242 (AUG) 3:0

Solid Mechanics

Analysis of stress, analysis of strain, stress-strain relations, two-dimensional elasticity problems, airy stress functions in rectangular and polar coordinates, axisymmetric problems, energy methods, St. Venant torsion, elastic wave propagation, elastic instability and thermal stresses.

Narasimhan R, Ramsharan Rangarajan

Fung, Y.C., Foundations of Solid Mechanics, Prentice Hall. Srinath,,L.S., Advanced Mechanics of Solids, Tata McGraw Hill.,Sokolnikoff, I.S., Mathematical Theory of Elasticity, Prentice Hall.~Fung Y C~Srinath. L. S.~Advanced Mechanics of Solids~Tata McGraw Hill.~Sokolnikoff~I. S.

ME 250 (AUG) 3:0

Structural Acoustics

Vibration and acoustic response of an infinite plate in contact with an acoustic half space to a line force (Crighton's solution). Complex variables, integration with branch cuts. Fluid-structure coupling in 2-D flexible-walled waveguides using asymptotic expansions (rectangular and cylindrical geometries). Coupling of sound with flexible enclosures. Sound radiation from finite rectangular plates and cylindrical shells. Transform and Rayleigh integral methods. Coincidence and wave number spectra, wave impedance, radiation efficiency.

Venkata R Sonti

Pre-requisite: Consent of Instructor Junger, M.C., and Feit, D., Sound, Structures and their Interaction, MIT Press,,1986. Fahy, F.J., Sound and Structural Vibration, Academic Press, 1985. Cremer, L., Heckl, M., and Ungar, E. E.,,Structure-Borne Sound, Springer-Verlag, 1987.~Fundamentals of acoustics ME249~Sound and Structure Interaction by Frank Fahy.

ME 260 (AUG) 3:0

Topology Optimization

Hierarchy in structural optimization: topology, shape, and size. Michelle continua and truss/frame topology optimization. Design parameterization and material interpolation: ground structure method, homogenization-based method, density distribution, level-set methods, peak function methods, phase-field methods. Numerical methods for topology optimization: optimality criteria methods, convex linearization and method of moving asymptotes, dual algorithms, numerical issues in the implementation of topology optimization algorithms, applications to multi-physics problems, compliant mechanisms and material microstructure design. Manufacturing constraints, other advanced topics.

Ananthasuresh G K

Pre-requisite: ME 256. Background in finite element analysis is preferred.,. Bendsoe,M.P.,and Sigmund,O.

ME 243 (AUG) 3:0

Continuum Mechanics

Introduction to vectors and tensors, finite strain and deformation-Eulerian and Lagrangian formulations, relative deformation gradient, rate of deformation and spin tensors, compatibility conditions, Cauchy's stress principle, stress tensor, conservation laws for mass, linear and angular momentum, and energy. Entropy and the second law, constitutive laws for solids and fluids, principle of material frame indifference, discussion of isotropy, linearized elasticity, fluid mechanics.

Chandrashekhar S Jog

Malvern,L.E.,Introduction to the Mechanics of a continuous medium,Prentice Hall,1969. Gurtin

ME 261 (AUG) 3:0

Engineering Mathematics

Vector and tensor algebra: Sets, groups, rings and fields, vector spaces, basis, inner products, linear transformations, spectral decomposition, tensor algebra, similarity transformations, singular value decomposition, QR and LU decomposition of matrices, vector and tensor calculus, system of linear equations (Krylov solvers, Gauss-Seidel), curvilinear coordinate transformations. Ordinary and partial differential equations: Characterization of ODEs and PDEs, methods of solution, general solutions of linear ODEs, special ODEs, Euler-Cauchy, Bessel's and Legendre's equations, Sturm-Liouville theory, critical points and their stability. Complex analysis: Analytic functions, Cauchy-Riemann conditions and conformal mapping. Special series and transforms: Laplace and Fourier transforms, Fourier series, FFT algorithms, wavelet transforms.

Chandrashekhar S Jog, Venkata R Sonti

Kryyzig E,Advanced Engineering Mathematics,C.R. W ylie,Advanced Engineering Mathematics,M.D. Greenberg

ME 289 (AUG) 3:0

Principles of Solar Thermal Engineering

Introduction, solar radiation – fundamentals, fluid mechanics and heat transfer, methods of collection and thermal conversion, solar thermal energy storage, solar heating systems, solar refrigeration, solar thermal elective conversion. Other applications.

Narasimham G S V L

Kreith,F.,and Kreider,J.F.,Principles of Solar Thermal Engineering

ME 228 (AUG) 3:0

Materials and Structure Property Correlations

Atomic structure of materials, atomic bonding, crystal structure. point, line and area defects in crystal structure. Solidification of metals, phase diagrams, Dislocation concepts of plastic deformation, critical resolved shear stress yeling interactions between dislocations and work hardening, Recovery, recrystallization and grain growth. Fracture-microscopic descriptions. Mechanisms of metal deformation, processing maps Concepts of bio-materials. Natural and synthetics, fracture and fatigue of bio-materials.

Satish V Kailas, Namrata Gundiah

Raghavan,V.,Materials Science and Engineers,Prentice Hall,1979. Davidge

ME 255 (AUG) 3:0

Principles of Tribology

Surfaces, theories of friction and wear, friction and wear considerations in design, viscosity, hydrodynamic lubrication, Reynolds equation, coupling of elastic and thermal equations with Reynolds equation. Elasto-hydrodynamic lubrication. Mechanics of rolling motion, hydrostatic lubrication, lubricants, tribometry, selection of tribological solutions.

Bobji M S

Halling,J. (ed.),Principles of Tribology,Macmillan,1975. Seireg

ME 297 (AUG) 1:0

Departmental Seminar

The student is expected to attend and actively take part in ME departmental seminars for one semester during his/her stay.

Aloke Kumar

ME 272 (JAN) 3:0

Thermal Management of Electronics

Structures of heat in electronic systems, review of heat transfer mechanisms with reference to electronic systems: foot prints, spreading resistance, design of fins, convection and radiation from electronic modules, jet impingement cooling, active cooling systems – adsorption, thermoelectric, phase change: current state of the art and future projections of thermal needs in electronics.

Pradip Dutta

Thermal Management of Electronic Systems, Vol. 1-4, ASME Press. Krauss, A.D., and Cohen, A.B.,,A.B., Thermal Management of Electronics, Hemisphere. ASME Trans. Journal of Electronic,Packaging IEEE Trans. on Components and Packaging Technologies.

ME 295 (JAN) 3:0

Geometric Modelling for Computer Aided Design

Representation of curves and surfaces-parametric form, Bezier, B. Spline and NURBS, intersection of curves and surfaces, interpolation, topology of surfaces, classification, characterization, elements of graph theory, representation of solids: graph based models and point set models, Euler operators, boundary evaluation, computation of global properties of solids.

Gurumoorthy B, Dibakar Sen

Piegl, L., and Tiller, W., The NURBS Book, Springer-Verlag, 1995. Mantyla, M., An Introduction to Solid Modeling, Computer Science Press, 1988.,Carter, J.S., How Surfaces Intersect in Space – An Introduction to Topology, World Scientific, 1993.,Fom enko, A.T., and Kunii, T.L., Topological Modeling for Visualization, Springer - Verlag, 1997.

ME 241 (JAN) 3:0

Experimental Engineering

Introduction to modeling of system response and sensor dynamics, Introduction to electronics, data acquisition and analysis, fluid velocity, stress, temperature measurement techniques. Experiments using photo-elasticity, universal testing machine, hot-wire anemometry, accelerometers.

Namrata Gundiah, Saptarshi Basu, Pramod Kumar

Doeblin, E.O., Measurement Systems: Application and design, McGraw Hill, 1990. Horowitz, P., and Hill, W.,,The art of electronics, Cambridge University Press, 1990.,Goldstein, R.J., Fluid mechanics measurements, Hemisphere Publishing Company, 1983.

ME 257 (JAN) 3:0

Finite Element Methods

Linear finite elements procedures in solid mechanics, convergence, isoparametric mapping and numerical integration. Application of finite element method to Poisson equation, calculus of variations, weighted residual methods, introduction of constraint equations by Lagrange multipliers and penalty method, solution of linear algebraic equations, finite element programming.

Chandrashekhar S Jog

Cook, R.D., Malkus, D.S., and Plesha, M.E., Concepts and Applications of Finite Element Analysis,,Third Edn, John Wiley, 1989.,Bathe, K.J., Finite Element Procedures, Prentice Hall of India, 1982.

ME 273 (JAN) 3:0

Solid and Fluid Phenomena at Small Scales

Intermolecular forces, surfaces, defects. Size- dependent strength, micro - mechanics of interfaces and thin films. Solvation forces, double layer forces, effect of physico-chemical forces on fluid flow at micron-scales. Slip boundary condition, friction and nano tribology. Nanoindentation, atomic force microscopy, micro-PIV and other characterizing techniques. MEMS, micro fluidics, microscopic heat pipes and other applications.

Raghuraman N Govardhan, Bobji M S

Israelachvili,J.N.,Intermolecular and Surface Forces,Elsevier Publishing Company,2003. Meyer

ME 284 (JAN) 3:0

Applied Combustion

Thermodynamics and Thermochemistry, Chemical equilibrium, adiabatic flame temperature, Chemical kinetics, Constant pressure and constant volume fixed-mass reactors, well-stirred reactor, Plug-flow reactor, Conservation Equations, Laminar Premixed and Diffusion Flames, Droplet Combustion, Introduction to Turbulent Combustion, Combustion in Gasoline and Diesel Engines, Combustion Chamber Design, Pollutant Formation, Exhaust after-treatment, Advanced Engine Concepts, Gas Turbine Combustors – design requirements, stability and emissions.

Ravikrishna, R. V.

An Introduction to Combustion, Stephen R. Turns, McGraw Hill, 2011. Combustion Engineering,,Kenneth W. Ragland and Kenneth M. Bryden, Taylor & Francis, 2011. Heywood, J.B., Internal,Combustion Engine Fundamentals, McGraw Hill Intl Edn, 1988.

ME 239 (JAN) 3:0

Modeling and Simulation of Dynamics Systems

Axioms of mathematical modeling, approximations and idealizations, fundamental balance laws, governing equations, state-space description, solution of ODEs, numerical methods for solutions of ODEs, explicit and implicit methods, error and accuracy, stability analysis of numerical solvers, stiff systems and stability, frequency domain in analysis of linear systems, FFT and power spectra, nonlinear systems, maps, bifurcations and chaos.

Rudra Pratap

Hirsh, M., and Smale, S., Differential Equations, Dynamical Systems and Linear Algebra, Academic Press, 1974. Farlow,S.J., Partial Differential Equations for Scientists and Engineers, Dover Publications Inc., 1993.,Pratap, R., Getting Started with MATLAB 7, Oxford University Press, 2006

ME 249 (JAN) 3:0

Fundamentals of Acoustics

Fundamentals of vibration, vibrations of continuous systems (strings and rods), I-D acoustic wave equation, sound waves in ducts, standing waves and travelling waves, resonances, complex notation, harmonic solutions, concept of impedance. Kirchoff-Helmholtz Integral Equation, spherical coordinates, spherical harmonics, Green function (Dirichlet and Neumann), Sommerfeld radiation condition, sound radiation from simple sources, piston in a baffle, pulsating sphere, piston in a sphere, vibrating free disc, scattering from a rigid sphere. Near field and far field, directivity of sources, wave guides (phase speed and group speed), lumped parameter modeling of acoustic systems, sound in enclosures (rectangular box and cylinders), Laplace Transforms and PDEs, 1-D Green Function, octave bands, sound power, decibels. Brief introduction to diffraction, scattering, reflection, refraction.

Venkata R Sonti

Kinsler, L.E., Frey, A.R., Coppens, A.B., and Sanders,,J.V., Fundamentals of Acoustics,,John W iley, 1982. Williams, E., Fourier Acoustics

ME 251 (JAN) 3:0

Biomechanics

Bone and cartilage, joint contact analysis, structure and composition of biological tissues. Continuum mechanics, constitutive equations, nonlinear elasticity, rubber elasticity, arterial mechanics. Introduction to cell mechanics.

Namrata Gundiah

Humphrey, J.D., Cardiovascular Solid Mechanics,Springer-Verlag, 2002. Fung, Y.C., Biomechanics,,Springer-Verlag, 1990. Holzapfel, G. A., Nonlinear Solid Mechanics, W iley, 2000.

ME 256 (JAN) 3:0

Variational Methods and Structural Optimization

Calculus of variations: functionals, normed vector spaces, Gateaux variation, Frechet differential, necessary conditions for an extremum, Euler-Lagrange multiplier theorem, second variations and sufficient conditions. Weak form of differential equations, application of Euler- Lagrange equations for the analytical solution of size optimization problems of bars and beams, topology optimization of trusses and beams applied to stiff structures and compliant mechanisms. Material interpolation methods in design parameterization for topology optimization, optimization formulations for structures and compliant mechanisms involving multiple energy domains and performance criteria. Essential background for Karush-Kuhn- Tucker conditions for multi-variable optimization, numerical optimization algorithms and computer programs for practical implementation of size, shape and topology optimization problems.

Ananthasuresh G K

Smith, D.R., Variational Methods in Optimization, Dover Publication, 1998. Haftka, R.T., and Gurdal, Z.,,Elements of Structural Optimization, Kluwer Academic Publishers, 1992.,Bendsoe, M.P., and Sigmund, O., Topology Optimization: Theory, Methods and Applications, Springer, 2003.

ME 288 (JAN) 3:0

Air Conditioning Engineering

Properties of air-water mixtures, psychometric chart, air conditioning processes, enthalpy potential, cooling and dehumidifying coils, cooling towers, heat transfer in buildings, comfort air conditioning, cooling load calculations, air conditioning system, design of air delivery systems, clean rooms and laminar flow equipment, air conditioning controls, noise and vibration control in air-conditioned rooms.

Narasimham G S V L

Jones, W.P., Air Conditioning Engineering, Fifth Edn, Butterworth Heinemann, Oxford, 2001. Croom e, D.J. and Roberts, B.M., Airconditioning and Ventilation of Buildings, Second Edn, Pergamon Press, Oxford, 1981.,Haines, R.W., and Hittle, D.C., Control Syst ems for Heating, Ventilating, and Air Conditioning, Sixth Edn, Springer Science plus Business Media, Inc., NY, 2003,ASHRAE Handbooks (SI Editions): HVAC Applications (2007), Systems and Equipment (2008), Fundamentals (2009).

ME 253 (JAN) 3:0

Vibrations of Plates and Shells

Shell coordinates, infinitesimal distances in curved shells, equations of motion for general shell structures using Hamilton's principle, specialization to commonly occurring geometries, detailed study of flat plates, rings, cylindrical shells and spherical shells, natural frequencies and modes, Rayleigh-Ritz and Galerkin methods, response to various types of loads (point forces, moments, moving loads), transient and harmonic loads, combination of structures using receptance.

Venkata R Sonti

Pre-requisite: a full course in lumped system vibrations,Werner Soedel ,Vibrations of plates and shells,S.S. Rao Vibrations of continuous systems

ME 299 (JAN) 0:27

Dissertation Project

The M. E. Project is aimed at training students to analyse independently any problem posed to them. The project may be a purely analytical piece of work, a completely experimental one, or a combination of both. In a few cases, the project may also involve sophisticated design work. The project report is expected to show clarity of thought and expression critical appreciation of the existing literature and analytical and/or experimental or design skill.

ME 274 (JAN) 3:0

Convective Heat Transfer

Energy equation, laminar external convection, similarity solution, integral method, laminar internal convection, concept of full development heat transfer in developing flow, turbulent forced convection, free convection from vertical surface, Rayleigh-Benard convection.

Pradip Dutta, Saptarshi Basu, Pramod Kumar

Pre-requisite: ME 201 and ME 271 Kays, W.M., and Crawford,,M.E., Convective Heat and Mass Transfer, Tata-McGraw Hill. Bejan, A.,,Convective Heat Transfer, John W iley.

ME 282 (JAN) 3:0

Computational Heat Transfer and Fluid Flow

Mathematical description of fluid flow and heat transfer, conservation equations for mass, momentum, energy and chemical species, classification of partial differential equations, coordinate systems. Discretization techniques using finite difference methods: Taylor series and control volume formulations. Irregular geometries and body-fitted coordinate system. Applications to practical problems.

Pradip Dutta, Ravikrishna, R. V., Ratnesh K Shukla, Gaurav Tomar

Pre-requisite: ME 201, ME 271 Patankar, S.V., Numerical Heat Transfer and Fluid Flow, Hemisphere Publishing Corporation, 1980,Anderson, D.A., Tannehill J.C., and Pletcher, R.H., Computational Fluid Mechanics and Heat Transfer, Hemisphere Publishing Corporation, 1984.,Versteeg, H.K., and Malalasekara, W., An Introduction to Computational Fluid Dynamics, Longman, 1995.

ME 287 (JAN) 3:0

Refrigeration Engineering

Methods of refrigeration, vapour compression refrigeration-standard and actual vapour compression cycles, multipressure systems, compressors, condensers, expansion devices, evaporators, refrigerants and refrigeration controls, component matching and system integration, vapour absorption refrigeration thermodynamics, single stage, dual stage and dual effect systems. Selection of working fluids, design of generators and absorbers, non- conventional refrigeration systems, vapour jet refrigeration.

Narasimham G S V L

Stoecker, W.F., and Jones, J.W., Refrigeration and Air conditioning, Second Edn, Tata McGraw Hill, 1982.,Therlkeld, J.L., Therm al Environm ent al Engineering, Prentice Hall, Inc., Englewood Cliffs, New Jersey, 1970.,ASHRAE Handbooks (SI Editions): Fundam entals (2009), Refrigeration (2010).

ME 298 (JAN) 3:0

Fluid Turbulence

Stability of fluid flows, transition to turbulence-introduction to turbulence, Reynolds averaged equations, statistical description of turbulence, vorticity dynamics, similarity methods, turbulent shear flows, Rayleigh Benard convention, modeling and numerical methods.

Jaywant H Arakeri

Pre-requisite: Consent of Instructor Tennekes H and Lumley J L,,A First Course in Turbulence, MIT 1972,Pope S.B., Turbulent Flows, Cambridge, 2000

ME 246 (JAN) 3:0

Introduction to Robotics

Robot manipulators: representation of translation, rotation, links and joints, direct and inverse kinematics and workspace of serial and parallel manipulators, dynamic equations of motion, position and force control and simulation.

Ashitava Ghosal

Ghosal, A., Robotics: Fundamental Concepts and Analysis,,Oxford University Press, 2006,Notes and recent research papers.

ME 244 (JAN) 3:0

Title: Experimental Methods in Microfluidics

Introduction to experimental methods used in microfluidic systems. Fundamentals of flows at the microscale; emphasis on visualization and quantification of fluid flow at the micron-scale. Brownian motion and its quantification. Particle image velocimetry (PIV), micro-particle image velocimetry (μ-PIV) and three-component flow measurement in three dimensions. Measuring displacement at the micron scale; digital image correlation (DIC). Thermometry at the micron-scale; laser induced fluorescence (LIF). Applications to microfluidic, biomicrofluidic and

Aloke Kumar

Background in fluid mechanics and transport phenomena is encouraged. Knowledge of statistical techniques will be beneficial, but not required.,Raffel, M., Willert, C., Wereley, S.T., Kompenhans, J, Particle Image Velocimetry, Springer, 2007,Nguyen, Nam-Trung, Wereley, S.T., Fundamentals and Applications of Microfluidics, Artech House, 2006,Li, Dongqing (Ed), Encyclopedia of Microfluidics and Nanofluidics, Springer, 2008

ME 290 (JAN) 3:0

Mechanics of slender elastic structures

Ramsharan Rangarajan

ME 293 (JAN) 3:0

Fracture Mechanics

Yogendra Simha K R, Narasimhan R

Dept of Materials Engineering

M. Tech. PROGRAMME MATERIALS ENGINEERING
(Duration : 2 Years, 64 credits)

Hard core (8 credits)

MT 202	3:0	Thermodynamics and Kinetics
MT 241	3:0	Structure and Characterisation of Materials
MT 243	0:2	Laboratory Experiments in Metallurgy

Soft core (9 credits): Any three out of the following eight courses

MT 203	3:0	Materials Design and Selection
MT 209	3:0	Defects in Materials
MT 220	3:0	Microstructural Design and Development of Engineering Materials
MT 231	3:0	Interfacial Phenomena in Materials Processing
MT 245	3:0	Transport Processes in Process Metallurgy
MT 252	3:0	Science of Materials Processing
MT 253	3:0	Mechanical Behaviour of Materials
MT 260	3:0	Polymer Science and Engineering – I

Project (32 credits)

MT 299 0:32 Dissertation Project

Electives (15 credits): At least 9 credits must be taken from the courses offered by the Department.

MT 209 (AUG) 3:0

Defects in Materials

Review of defect classification and concept of defect equilibrium. Review of point defects in metallic, ionic and covalent crystals. Dislocation theory - continuum and atomistic. Dislocations in different lattices. Role of anisotropy. Dislocation kinetics. Interface thermodynamics and structure. Overview of grain boundaries, interphase boundaries, stacking faults and special boundaries. Interface kinetics: migration and sliding. Defect interactions: point defect-dislocation interaction, dislocation-interface interactions, segregation, etc.. Overview of methods for studying defects including computational techniques

Karthikeyan Subramanian

W.D. Kingery, H.K. Bowen and D.R. Uhlmann: Introduction to Ceramics, 2nd ed., John Wiley and Sons, 1976~D. Hull and D. J. Bacon: Introduction to dislocations, 4th ed., Butterworth-Heinemann, 2001.~D.A. Porter and K.E. Easterling: Phase Transformation in Metals and Alloys, 2nd ed. Chapman and Hall, 1992.~R.W. Balluffi, S.M. Allen, W.C. Carter: Kinetics of Materials, 1st ed. Wiley-Interscience, 2005.~J.P. Hirth and J.L. Lothe: Theory of Dislocations, 2nd ed., Krieger, 1982.

MT 202 (AUG) 3:0

Thermodynamics and Kinetics

Classical and statistical thermodynamics, Interstitial and substitutional solid solutions, solution models, phase diagrams, stability criteria, critical phenomena, disorder-to-order transformations and ordered alloys, ternary alloys and phase diagrams, Thermodynamics of point defects, surfaces and interfaces. Diffusion, fluid flow and heat transfer.

Abinandanan T A

C.H.P. Lupis: Chemical Thermodynamics of Materials, Elsevier Science, 1982~P. Shewmon: Diffusion in Solids, 2nd Edition, Wiley, 1989.~A.W. Adamson and A.P. Gast: Physical Chemistry of Surfaces (Sixth Edition), John Wiley, 1997.

MT 218 (AUG) 3:0

Modeling and Simulation in Materials Engineering

Importance of modeling and simulation in Materials Engineering. nd numerical approaches. Numerical solution of ODEs and PDEs, explicit and implicit methods, Concept of diffusion, phase field technique, modelling of diffusive coupled phase transformations, spinodal decomposition. Level Set methods, Celula Automata,: simple models for simulating microstructure,. Finite element modelling,: Examples in 1D, variational approach, interpolation functions for simple geometries, (rectangular and triangular elements); Atomistic modelling techniques,: Molecular and Monte-Carlo Methods.

Abhik N Choudhury

A.B. Shiflet and G.W. Shiflet: Introduction to Computational Science: Modeling and Simulation for the Sciences, Princeton University Press, 2006.~D.C. Rapaport: The Art of Molecular Dynamics Simulation, Cambridge Univ. Press, 1995.~K. Binder, D. W. Heermann: Monte Carlo Simulation in Statistical Physics, Springer, 1997.~K.G.F Janssens, D. Raabe, E. Kozeschnik, M.A. Miodownik, B. Nestler: Computational Materials Engineering: An Introduction to Microstructure Evolution, Elsevier Academic press, 2007.~David V. Hutton, Fundamentals of Finite Element Analysis

MT 235 (AUG) 3:0

Corrosion Technology

Basic electrochemical principles governing corrosion. Types and mechanisms of corrosion. Advances in corrosion engineering and control. Anodic and Cathodic control-Biocorrosion, mechanisms and microbiological aspects. Corrosion under sub-soil and sea water conditions- Marine biofouling and biocorrosion with respect to industrial conditions. Methods of abatement.

Abinandanan T A

M.G. Fontana: Corrosion Engineering, 3rd Edition, McGraw-Hill, N.Y., 1978.~Borenstein: Microbiologically Influenced Corrosion Handbook.

MT 260 (AUG) 3:0

Polymer Science and Engineering

Fundamentals of polymer science. Polymer nomenclature and classification. Current theories for describing molecular weight, molecular weight distributions. Synthesis of monomers and polymers. Mechanisms of polymerization reactions. Introduction to polymer processing (thermoplastic and thermoset). Structure, property relationships of polymers: crystalline and amorphous states, the degree of crystallinity, cross-linking, and branching. Stereochemistry of polymers. Instrumental methods for the elucidation of polymer structure and properties; basic principles and unique problems encountered when techniques such as thermal (DSC, TGA, DMA, TMA, TOA), electrical, and spectroscopic (IR, Raman, NMR, ESCA, SIMS) analysis GPC, GC-MS, applied to polymeric materials. Polymer Processing - Injection Molding, Extrusion, Compression Molding, Blow Molding, Casting and Spin Coat, Calendaring.

Praveen C Ramamurthy

G. Odian: Principles of Polymerization. McGraw Hill. 2nd Edition.. 1981. N.A. Dotson. R. Galvan. R.L. Laurence and M. Tirrell: Polymerization Process Modeling. Wiley. 1995. F.W. Billmeyer: Textbook of Polymer Science, Wiley. 1984.

MT 253 (AUG) 3:0

Mechanical Behaviour of Materials

Theory of Elasticity. Theory of Plasticity Review of elementary dislocation theory. Deformation of single and polycrystals. Temperature and strain rate effects in plastic flow - strain hardening, grain size strengthening, solid solution strengthening, order hardening, precipitation hardening, dispersion strengthening. Strengthening by martensitic transformation, creep, fatigue and fracture.

Subodh Kumar

Subodh Kumar,Thomas H. Courtney,Mechanical Behaviour of Materials.,G.E. Dieter: Mechanical Metallurgy,McGraw-Hill

MT 245 (AUG) 3:0

Transport Processes in Process Metallurgy

Basic and advanced idea of fluid flow, heat and mass transfer. Integral mass, momentum and energy balances. The equations of continuity and motion and its solutions. Concepts of laminar and turbulent flows. Concept of packed and fluidized bed. Non-wetting flow, Natural and forced convection. Unit processes in process metallurgy. Application of the above principles in process metallurgy.

Govind S Gupta

J. Szekely and N.J. Themelis, Rate Phenomena in Process Metallurgy, Wiley, New York, 1971~G.H. Geiger and D R Poirier: Transport Phenomena in Metallurgy, Addison-Wesley, 1980.~D.R. Gaskell: Introduction to Transport Phenomena in Materials Processing, 1991.~R.B. Bird, W.E. Stewart and E.N. Lightfoot: Transport Phenomena, John Wiley International Edition, 1960~F.M. White: Fluid Mechanics, McGraw Hill, 1994 Various research papers

MT 241 (AUG) 3:0

Structure and Characterization

Bonding and crystal structures, Stereographic projection, Point and space groups, Defects in crystals, Schottky and Frenkel defects, Charged defects, Vacancies and interstitials in non stoichiometric crystals, Basics of diffraction theory, X-ray powder diffraction and its applications, Electron diffraction and Electron microscopy.

Rajeev Ranjan

A. R. West: Solid State Chemistry and its Applications, John Wiley~B. D. Cullity: Elements of x-ray Diffraction~A. Kelly and G. W. Groves: Crystallography and Crystal Defects, Longman~M. D. Graef and M. E. Henry: Structures of Materials, Cambridge~R. J. D. Tilley: Defects in Solids, Wiley 2008

MT 258 (JAN) 3:0

Mechanical Behavior of Thin Films

Short description of common thin film deposition techniques; Origin of residual stresses; Determination of stress state in thin films deposited on substrate; Stress relaxation processes, including hillocking and whiskering, grain boundary sliding, and interface governed phenomenon, such as dewetting, buckling, interfacial fracture, interfacial sliding, etc.; Size effects; Mechanical testing of thin films, including nanoindentation.

Praveen Kumar

Materials Science of Thin Films by M. Ohring,Academic Press,Thin film materials: stress,defect formation and surface evolution. L. B. Freund,S. Suresh

MT 250 (JAN) 3:0

Introduction to Materials Science and Engineering

Compulsory for M.E. students who do not have BE Metallurgy; Compulsory for research students without materials background

Bonding, types of materials, basics of crystal structures and crystallography. Thermodynamics, thermochemistry, unary systems. Methods of structural characterisation. 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 material systems: metallic alloys, ceramics, semiconductors, composites

Subodh Kumar

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

MT 208 (JAN) 3:0

Diffusion in Solids

Aloke Paul

Paul G. Shewmon, Diffusion in Solids,A. Paul, T. Laurila, V. Vuorinen, S. Divinski, Thermodynamics, Diffusion and The Kirkendall effect in Solids,A. Paul, S. Divinski, Handbook of Solid State Diffusion

MT 213 (JAN) 3:0

Electronic Properties of Materials

Introduction to electronic properties; Drude model, its success and failure; energy bands in crystals; density of states; electrical conduction in metals; semiconductors; semiconductor devices; p-n junctions, LEDs, transistors; electrical properties of polymers, ceramics, metal oxides, amorphous semiconductors; dielectric and ferroelectrics; polarization theories; optical, magnetic and thermal properties of materials; application of electronic materials: microelectronics, optoelectronics and magnetoelectrics.

Subho Dasgupta

R. E. Hummel, Electronic Properties of Materials,S. O. Kasap, Principles of Electronic Materials and Devices,S. M. Sze, Semiconductor devices: Physics and Technology,D. Jiles, Introduction to the electronic properties of materials

MT 225 (JAN) 3:0

Deformation and Failure Mechanisms at Elevated Temperatures

Phenomenology of Creep, Microstructural considerations in metals, alloys, ceramics and composites. Creep mechanisms, Deformation mechanism maps, Superpasticity in metal alloys, ceramics and nanophase materials, Commercial applications and considerations, Cavitation failure at elevated temperatures by nucleation, growth and interlinkage of cavities.

The course will also include some laboratory demonstrations of the phenomena discussed in the class together with an appropriate analysis of the data.

Atul H Chokshi

Atul H Chokshi,J. P. Polreer, Creep of Crystals, Cambridge University Press, Cambridge, 1984,H. Riedel, .Fracture at High Temperatures, Springer Verlag, Berlin, 1987

MT 256 (JAN) 3:0

Fracture

Review of elastic and plastic deformation. Historical development of fracture mechanics. Thermodynamics of fracture including Griffith theory. Linear elastic fracture mechanics. Irwin and Dugdale extensions. Stability of cracks. Crack resistance curves and toughening of brittle materials. Ductile failure. J-integral. Indentation failure. Environmental aspects of failure. Cyclic Fatigue. Methods to measure toughness. Fracture in thin films and interfaces. Toughening in hierarchical structures

Vikram Jayaram

B.R. Lawn: Fracture of Brittle Solids. Cambridge University Press (1993).,T.H. Courtney: Mechanical Behaviour of Materials. McGraw Hill (1990).,David Broek: Engineering Fracture Mechanics. . Sijthoff and Nordhoff , The Netherlands (1978).,Richard Hertzberg: Deformation & Fracture of Engineering Materials. John Wiley (1996).

MT 299 (JAN) 0:32

Dissertation Project

The M.E. Project is aimed at training the students to analyse independently any problem posed to them. The project may be a purely analytical piece of work. a completely experimental one or a combination of both. In a few cases. the project can also involve a sophisticated design work. The project report is expected to show clarity of thought and expression. critical appreciation of the existing literature and analytical and/or experimental or design skill.

MT 231 (JAN) 3:0

Interfacial Phenomena in Materials Processing

Materials and surfaces, Adsorption from solution, Thermodynamics of adsorption - surface excess and surface free energy, Gibbs equation, adsorption isotherms, wetting, contact angle, Young's equation, Monolayer and interfacial reactions, Electrical phenomena at interfaces, electrochemistry of the double layer, electrokinetics, flocculation, coagulation and dispersion, Polymers at interfaces, Emulsions. Applications in Materials Processing.

Subramanian S

E. Matrijivic (Ed.): Surface and Colloid Science, Plenum, New York, 1982.,A.W. Adamson: Physical Chemistry of Surfaces, Wiley Interscience, New York, 1996.,J.S. Laskowski and J. Ralston (Ed.): Colloid Chemistry in Mineral Processing, Elsevier, New York, 1992.

MT 248 (JAN) 3:0

Modelling and Computational Methods in Metallurgy

Basic principles of physical and mathematical modelling. Similarity criteria and dimensional analysis. Detailed study of modelling of various metallurgical processes such as blast furnace, induction furnace, ladle steelmaking, rolling, carburizing and drying. Finite difference method. Solution of differential equations using various numerical techniques. Convergence and stability criteria.

Assignments will be based on developing computer code to solve the given problem. Prerequisite: Knowledge of transport phenomena, program language

Govind S Gupta

Govind S Gupta,J.Szekely and N. J. Themelis: Rate Phenomena in Process Metallurgy, Wiley, New York, 1971,B. Carnahan, H. A. Luther, and J. O. Wikes: Applied Numerical Methods, John Wiley, NY 1969.

MT 243 (JAN) 0:2

Laboratory Experiments in Materials Engineering

Experiments in Metallographic techniques, heat treatment, diffraction mineral beneficiation, chemical and process metallurgy, and mechanical metallurgy.

Rajeev Ranjan

MT 201 (JAN) 3:0

Phase Transformations

Overview of phase transformations, nucleation and growth theories, coarsening, precipitation, spinodal decomposition, eutectoid, massive, disorder-to-order, martensitic transformations. crystal interfaces and microstructure. topics in the theory of phase transformations: linear stability analysis, elastic stress effects, sharp interface and diffuse interface models of microstructural evolution.

Chandan Srivastava

Prerequisites: Basic courses on crystallography, thermodynamics, phase diagrams and diffusion.,D.A. Porter. and K.E. Easterling: Phase Transformations in Metal and Alloys, Van Nostrand, 1981.,A.K. Jena, and M. Chaturvedi: Phase Transformations in Materials, Prentice-Hall, 1993.,A.G. Khachaturyan: Theory of Structural Transformation in Solids, John Wiley, 1983.,R.E. Reed-Hill and R. Abbaschian: Physical Metallurgy Principles, P.W.S-Kent, 1992.

MT 255 (JAN) 3:0

Solidification Processing

Advantage of solidification route to manufacturing, the basics of solidification including fluid dynamics, solidification dynamics and the influence of mould in the process of casting. Origin of shrinkage, linear contraction and casting defects in the design and manufacturing of casting, continuous casting, Semi-solid processing including pressure casting, stir casting and thixo casting. Welding as a special form of manufacturing process involving solidification. Modern techniques of welding, the classification of different weld zones, their origin and the influence on properties and weld design. Physical and computer modeling of solidification processes and development of expert systems. New developments and their possible impact on the manufacturing technology in the future with particular reference to the processes adaptable to the flexible manufacturing system.

Abhik N Choudhury

Abhik N Choudhury,J. Campbell: Casting, Butterworth - Haneman, London, 1993,M.C. Flemings: Solidification Processing , McGraw Hill, 1974.

MT 257 (JAN) 3:0

Finite Element Method for Materials Engineers

This course has been specially designed for those students, who did not get a chance to study FEM during undergrad, but want to use FEM as a tool to gain some insight into their project/research problems. The syllabus includes the following: Quick recap of relevant mathematical concepts. Introduction to fundamentals of elasticity and plasticity. Crystal plasticity. Philosophy of FEM. Fundamentals of FEM, such as concepts of meshing, stiffness matrix, interpolation functions. Residual methods, Rayleigh - Ritz method, Galerkin method. 1-D, 2-D and 3-D example problems in elasticity and heat transfer. Solving linear and non-linear structural, thermal and electrical problems using a commercial FEM software (mostly, ANSYS). Finite element crystal plasticity.

Praveen Kumar,Cook,R. D.,et al,Concept and Applications of Finite Element Analysis

MT 261 (JAN) 3:0

Organic Electronics

(Prerequisites: Polymer Science and Engineering and Semiconductor fundamentals) Fundamentals of polymers. Device and materials physics. Polymer electronics materials, processing, and applications. Chemistry of device fabrication, materials characterization. Electroactive polymers. Device physics: Crystal structure, Energy band diagram, Charge carriers, Heterojunctions, Diode characteristics. Device fabrication techniques: Solution, Evaporation, electrospinning. Devices: Organic photovoltaic device, Organic light emitting device, Polymer based sensors.Stability of organic devices.

Praveen C Ramamurthy

T. A. Skotheim and J. R. Reynolds (Editors): Handbook of Conducting Polymers (Third Edition) Conjugated Polymers: Theory, Synthesis, Properties and Characterization, CRC Press.,T.A. Skotheim and J. R. Reynolds (Editors): Handbook of Conducting Polymers (Third Edition) Conjugated Polymers: Processing and Applications Edited by Terje A. Skotheim and John R. Reynolds, CRC Press.,S-S. Sun and N. S. Sariciftci (Editors): Organic Photovoltaics - Mechanisms, Materials, and Devices, CRC Press.,D.A. Neamen: Semiconductor Physics and Devices Basic Principles, McGraw Hill.

MT 271 (JAN) 3:0

Introduction to Biomaterials Science and Engineering

This course will introduce basic concepts of biomaterials research and development including discussion on different types of materials used for biomedical applications and their relevant properties. Content: Surface engineering for biocompatibility; Protein adsorption to materials surfaces; Blood compatibility of materials; Immune response to materials; Corrosion and wear of implanted medical devices; Scaffolds for tissue engineering and regenerative medicine; Concepts in drug delivery;

Kaushik Chatterjee

Ratner et al: Biomaterials science: An introduction to materials in medicine,Lecture notes,Literature

MT 262 (JAN) 3:0

Concepts in Polymer Blends and Nanocomposites

Introduction to polymer blends and composites, nanostructured materials and nanocomposites, Polymer-polymer miscibility, factors governing miscibility, immiscible systems and phase separation, Importance of interface on the property development, compatibilizers and compatibilization, Blends of amorphous & semi-crystalline polymers, rubber toughened polymers, particulate, fiber reinforced composites. Nanostructured materials like nano clay, carbon nanotubes, graphene etc. and polymer nanocomposites. Surface treatment of the reinforcing materials and interface/interphase structures of composites / nanocomposites. Various processing techniques like solution mixing, melt processing. Unique properties of blends, composites/nanocomposites in rheological, mechanical, and physical properties and applications

Suryasarathi Bose

D.R. Paul and S. Newman: Polymer Blends, Vol 1&2 , Academic Press, 2000,L.A. Utracki: Polymer Alloys and Blends, Hanser, 2000,C. Chung: Introduction to Composites, Technomic, Lancaster, PA. 1998.,J. Summerscales and D. Short: Fiber Reinforced Polymers, Technomic. 1988,T.J. Pinnavia and G.W. Beall (Editors): Polymer-Clay Nanocomposites, Wiley, New York 2000. P.M. Ajayan, L.S. Schadler and P.V. Braun: Nanocomposite Science &Technology, Wiley-VCH, Weinheim, 2003.

MT 220 (JAN) 3:0

Microstructural Engineering of Structural Materials

Review of crystal defects: dislocation theory, grain boundaries and heterophase boundaries, defect kinetics and defect interactions; Role of microstructure on mechanical properties: strengthening mechanisms, ductilizing mechanisms, toughening mechanisms, effect of microstructure on creep, fatigue and impact resistance; Methods of controlling microstructures: phase transformations (L?S, V?S, S? S), heat treatments, solidification, mechanical processing, texture control, recovery and recrystallization, sintering, etc; Case studies of microstructural control of engineering metals, alloys and ceramics (Ni-base superalloys, YSZ, ceramic-matric composites, Ti-alloys, steels, etc)

Karthikeyan Subramanian, Dipankar Banerjee, Abhik N Choudhury

Centre for Product Design and Manufacturing

M Des Programme
Product Design and Engineering
Duration: 2 years

Core Courses: 36 credits from the following pool

PD 201 2:1 Elements of Design
PD-202 2:1 Elements of Solid and Fluid Mechanics
PD 203 2:1 Creative Engineering Design
PD 205 2:1 Materials, Manufacturing and Design
PD 207 1:2 Product Visualization, Communication and Presentation
PD 209 3:0 Product Planning and Marketing
PD 211 2:1 Product Design
PD 212 2:1 Computer Aided Design
PD 216 2:1 Design of Automotive Systems
PD 218 2:1 Design Management
PD 219 0:3 Mini Design Project
PD 229 0:3 Computer Aided Product Design
PD 231 2:1 Applied Ergonomics
PD 235 2:1 Mechanism Design
PD 239 0:3 Design and Society

Project: 16 Credits

PD 299 0:16 Dissertation Project

Electives: The balance of credits to make up a minimum of 64 credits required to complete the programme may be chosen as electives from within or outside the department, with the approval of the DCC/ Faculty Advisor.

PD 209 (AUG) 2:1

New Product Development: Concepts and Tools

Technology-based products, business context, front-end of innovation, opportunity identification, target markets, integrated teams, product features, differentiation from competition, business cases, product architecture, designing and prototyping products, planning for manufacturing capabilities, marketing and sales programs

Gurumoorthy B

(1) Ulrich, K.T., and Eppinger, S.D., Product Design and Development, 2nd edition, (2) Philip Kotler, Kevin Lane Keller, Marketing Management, 15th edition, (3) Douglas Smith and Jon Katzenbach, The Wisdom of Teams: Creating the High-Performance Organization, 2015 edition.

PD 231 (AUG) 2:1

Applied Ergonomics

Introduction to ergonomics. Elements of anthropometry, physiology, anatomy, biomechanics and CTDs. Workspace, seating, hand tool design, manual material handling. Man-machine system interface, human information processing, displays and controls, compatibility. Environmental factors, cognitive ergonomics, principles of graphic user interface design, human error, product safety, product liability.

Dibakar Sen, Rina Maiti

(1) Sanders and McCormick,Human Factors in Engineering and Design,,Seventh Edn,McGraw Hill

PD 205 (AUG) 2:1

Materials, Manufacturing and Design

Material usage and sustainability issues, concept or closed and open loop. Engineering materials, metals and their properties, uses, processing methods, design data and applications, material selection criteria, manufacturing and processing of materials. Plastics and composites, types, classification, properties, processing techniques and limitations, basics of reliability, failure and failure analysis.

Satish V Kailas

Dieter, G.E., Engineering Design – A Materials and processing approach, McGraw Hill, 1991.,Ashby, M.F., Materials selection in Mechanical Design, Pergamon press, 1992.,Patton, W.J., Plastics Technology, Theory, Design and Manufacture, Lenton Publishing Co.

PD 207 (AUG) 1:2

Product Visualization, Communication and Presentation

Object drawing fundamentals, theory of perspectives, exploded views, sectional views. Fundamentals of lighting, idea representation and communication methods and pitfalls. Materials, tools and techniques of representation in various media like pencil, ink, colour etc. Rendering techniques, air brush illustration. Idea documentation. Fundamentals of photography, video-graphy and digital media. Dark room techniques. Studio assignments in all the above topics. Mock-up modeling and simulation in various materials

Shivakumar N D

Geometry of design: Studies in proportion and composition, ISBN : 1568982496,Foundation of Art & Design 1856693759,Earle, J.E., Engineering Design Graphics, Addison Wesley, ISBN 020111318x

PD 201 (AUG) 2:1

Elements of Design

Visual language, visual elements, visual perception, visual deception. Universal principles of design. Theory of colour, studies in form, graphic compositions, grid structure, spatial analysis and organization. Visual expressions in nature.

Shivakumar N D

Young, F.M., Visual Studies, Prentice-Hall, USA.,Lidwell, W., Holden, K., and Butler, J., Universal Principles of Design, Rockport, USA.,Evans, P., and Thomas, M., Exploring the Elements of Design, Thomson, USA.

PD 202 (AUG) 2:1

Elements of Solid and Fluid Mechanics

Analysis of stress and strain, failure criteria, dynamics and vibrations. Control of engineering systems, elements of fluid mechanics drag and losses, thermal analysis, problems in structural and thermal design.

Jaywant H Arakeri, Gurumoorthy B

Shigley, J.E., Mechanical Engineering Design, McGraw Hill.,White, F.M., Fluid Mechanics, Tata McGraw Hill.,Gupta, V., Elements and Heat and Mass Transfer, Sage Publishers.

PD 203 (AUG) 2:1

Creative Engineering Design

Design: definitions, history and modern practice. Design and society, design and the product life cycle. Methodology for problem solving in engineering design: recognition, definition, analysis, synthesis, communication and presentation. Hands-on projects.

Amaresh Chakrabarti

Jones, J.C., Design Methods, John Wiley, 1981.,Cross, N., Engineering Design Methods, John Wiley, 1994.,Pahl, G., and Beitz, W., Engineering Design, Design Council, 1984.,Brezet and van Hammel, ECODESIGN – A promising approach to sustainable production and consumption, UNEP Manual

PD 217 (AUG) 2:1

CAE in Product Design

Product development driven by concurrent engineering, role of Computer-Aided Engineering (CAE) in product design. Mathematical abstractions of products for functionality verification; lumped mass, finite element, boundary element, and statistical modeling procedures. Use of commercial finite element-based packages for design analysis and optimization.

Anindya Deb

Bathe, K.J., Finite Element Procedures, Prentice Hall, 1995.,Robert Cook, Finite Element Modeling for Stress Analysis, 1995.,Banerjee, P.K., Boundary Element Methods in Engineering Science, McGraw Hill.

PD 232 (AUG) 2:1

Human Computer Interaction

Basic theories of visual and auditory perception, cognition, rapid aiming movement and their implications in electronic user interface design, Concept of user modelling, Multimodal interaction, Eye gaze and finger movement controlled user interface, Target prediction technologies in graphical user interface, usability evaluation, User study design, Basic principles of experiment design, Conducting t-test and one-way and repeated measure ANOVA, Parametric and nonparametric
statistics, Interaction design for automotive and aviation environments, HCI in India, Writing International standards through ITU and ISO.

Pradipta Biswas

Shneiderman B "Designing the User Interface - Strategies for Effective Human-Computer Interaction. " Pearson Education,Buxton B."Sketching User Experiences: Getting the Design Right and the Right Design",Field A. "Discovering Statistics Using SPSS." SAGE Publications Ltd.

PD 233 (AUG) 2:1

Design of Biomedical Devices and Systems

Medical Device Classification, Bioethics and Privacy, Biocompatibility and Sterilization Techniques,Design of Clinical Trials, Design Control & Regulatory Requirements, Introduction to specific medical technologies: Biopotentials measurement (EMG, EOG, ECG, EEG), Medical Diagnostics (In-vitro diagnostics), Medical diagnostics (Imaging), Minimally Invasive Devices, Surgical Tools and Implants, Medical Records and Telemedicine. The course will include guest lectures by healthcare professionals giving exposure to ummet needs in the healthcare technologies and systems.

Manish Arora

Paul H king, Richard C. Fries, Arthur T. johnson, Design of Biomedical Devices and Systems. Third edition, ISBN 9781466569133,Peter J. Ogrodnik, Medical Device Design:Innovation from Concept to Market, Academic Press Inc; ! edition(2012), ISBN- 10:0123919428,Stefanos Zenios, Josh Makower, Paul Yock, Todd J. Brinton, uday N. Kumar, Lyn Denend, Thomas M. Krummel,,Biodesign: the PRocess of Innovating Medical Technologies, Cambridbge University press; 1 edition(2009), ISBN- 10:0521517427

PD 229 (AUG) 0:3

Computer Aided Product Design

Project in re-engineering a product using computer tools for reverse engineering geometry and intent, design evaluation, modification and prototyping.

Ashitava Ghosal, Gurumoorthy B

PD 239 (AUG) 0:3

Design and Society

Independent study/research on a chosen topic by students under the supervision of faculty members. Presentation of seminar on work done. The course also includes invited seminars on various aspects of product design and marketing issues. The focus is on real life situations from practicing professionals.

PD 234 (JAN) 2:1

Intelligent User Interface

Basics of Artificial Intelligence(heuristic and state space search,Bayes Ru

Pradipta Biswas

Shneiderman B. "Designing The User Interface - Strategies for Effective Human-Computer Interaction.",Buxton B., Sketching User Experiences: Getting the Design Right and the Right Design, Morgan Kaufmann,Norman K (Ed), Wiley Handbook of Human Computer Interaction, Wiley 2017

PD 229 (JAN) 0:3

Computer Aided Product Design

Project in re-engineering a product using computer tools for reverse engineering geometry and intent, design evaluation, modification and prototyping.

Ashitava Ghosal, Gurumoorthy B

PD 236 (JAN) 2:1

Embodiment Design

Embodiment methodology, basic components and interfaces, design for performance including strength, usability, maintenance and reliability, Design for manufacturing, assembly, packaging, distribution, services, cost and environmental impact. Dimensioning, tolerance and standards

Gurumoorthy B, Satish V Kailas, Dibakar Sen, Amaresh Chakrabarti

Pahl, G and Beitz, W, Engineering design - A systematic Approach, Springer, 2007,karl T. Ulrich and Steven D. Eppinger,Product Design and Development. McGraw -Hill 2000,Ehrelspiel. K, and Lindemann U Cost efficient Design, Springer,,2007,Whitney, DE. Mechanical Assemblies and their Role in Product Development, ISBN 13: 978-0195157826

PD 221 (JAN) 2:1

Methodology for Design Research

Introduction to design research, a methodology for design research and its components, types of design research, selecting criteria and its research methods, understanding factors influencing design and its research methods, developing design support and its research methods, evaluating design support and its research methods, associated exercises and tests.

Amaresh Chakrabarti, Pradipta Biswas

Blessing, L.T.M., Chakrabarti, A., and Wallace, K.M., An Overview of Design Studies in Relation to a Design Research Methodology.,Frankengerger and Badke-Schaub (Eds), Designers: The Key to Successful Product Development, Springer Verlag, 1998.,Current Literature including papers from Proceedings of the International Conference in Engineering Design, Prague, 1995

PD 216 (JAN) 2:1

Design of Automotive Systems

Classification of automotive systems, interfacing of marketing, design and manufacturing, converting customer's needs into technical targets, vehicle design process milestones with a systems engineering approach, trade-off studies, manufacturing cost and economic feasibility analysis. Design tools such as reverse engineering, rapid prototyping, CAD/CAE, Taguchi methods, and FMEA. Styling concepts and features, ergonomics, packaging and aerodynamics. Review of vehicle attributes (NVH, durability, vehicle dynamics, crash safety, etc.). Overview of automotive technology (body, power train, suspension systems, etc.).

Anindya Deb

Ulrich, K.T., and Eppinger, S.D., Product Design and Development, Second Edn, Irwin McGraw Hill,Gillespie, T.D., Fundamentals of Vehicle Dynamics, SAE Inc..,Schwaller, A.E., Motor Automotive Technology, Third Edn, Delman Publishers

PD 218 (JAN) 2:1

Design Management

Designers' perspective of the market, designers and psychological issues, perception, errors in perception, designers' sources of product features: projective techniques to acquire product feature databases. Designer in a team: human resources issues a designer must know, designer and competition, collaboration and conflict management, designer in an organization, designer as an entrepreneur, designers' knowledge on intellectual property.

Gurumoorthy B

Oakley,M. (Ed),Design Management,– A Handbook of Issues and Methods,Blackwell Publication

PD 211 (JAN) 2:1

Product Design

Semiotic studies – product semantics, syntactics, and pragmatics. Study of expressions, metaphors, feelings, themes. Study of product evolution, problem identification, design methods, design process, design brief, concept generation, concept selection, design and development, product detailing, prototyping, design evaluation.

Shivakumar N D

Papanek, V., Design for the Real World, Thames & Hudson, London.,Ulrich, K.T., and Eppinger, S.D., Product Design and Development,Tata McGraw Hill, India

PD 212 (JAN) 2:1

Computer Aided Design

CAD – modeling of curves, surfaces and solids manipulation of CAD models, features based modeling, parametric/ variational modeling, product data exchange standards. Introduction to CAID, surfaces. Interfacing for production and tool design, photo rendering and scanning, 3D animation and morphing, studio exercise in virtual products and systems.

Gurumoorthy B

Zeid, I.,,CAD/CAM,,McGraw Hill

PD 215 (JAN) 2:1

Mechatronics

Introduction to mechatronics – overview of mechatronic products and their functioning. Survey of mechatronical components, selection and assembly for precision-engineering applications. Study of electromechanical actuators and transducers. Load analysis and actuator selection for typical cases such as computer peripherals. Study of electronic controllers and drives for mechanical products. Interfacing of mechanical and electronic systems. Design assignments and practical case studies.

Manish Arora

Bolton, W Mechatronics, Longman, 2015,Kuo, B.C., D.C.Motors and Control systems, SRL Publishing Co., 1979.,Kuo, B.C., Step Motors and Control Systems, SRL Publishing Co., 1979.

PD 235 (JAN) 2:1

Mechanism Design

Machines and mechanisms, links, pairs, degrees of freedom, kinematic chain, inversions. Kinematic analysis of simple mechanisms by graphical and analytic methods, static force analysis. Dimensional synthesis of four bar mechanism, application of coupler curves for dwell mechanisms, two and three position rigid body guidance. Cams, displacement curves and profile generation. Gears, profiles, cycloidal and involute, contact ratio. Spur, bevel, helical, worm gearing. Analysis of gear trains, mechanisms for specific functions.

Dibakar Sen

Sandor, G.N., and Erdman, A.G., Advanced Mechanism Design, Volumes I & II, Prentice Hall of India Limited, New Delhi.,Hirschhorn, J., Kinematics and Dynamics of Plane Mechanisms, McGraw-Hill, 1962,Mabie, H.E., and Ocvirk, F.W., Mechanisms and Dynamics of Machinery, John Wiley and sons, New York.,Current Literature

PD 299 (JAN) 0:16

Dissertation Project

Spread over 15 months, commencing immediately after the second semester. It involves complete design and prototype fabrication with full documentation.

PD 239 (JAN) 0:3

Design and Society

Independent study/research on a chosen topic by students under the supervision of faculty members. Presentation of seminar on work done. The course also includes invited seminars on various aspects of product design and marketing issues. The focus is on real life situations from practicing professionals.

Centre for Sustainable Technologies

ST 210 (AUG) 3:1

Principles and Applications of GIS and Remote Sensing

Key concepts and principles of remote sensing, GIS and digital image processing. Tools to address environmental problems. Roles of professionals in managing environment in their respective areas

Ramachandra TV

Lillesand,T.M.,and Kiefer,R.W.,Remote Sensing and Image Interpretation

ST 204 (AUG) 1:1

Sustainable Energy and Environment lab

Energy conversion technologies, functional performance of buildings (thermal comfort, lighting, BIPV), water quality, building technologies, fundamentals of sustainability

Venkatarama Reddy B V, Dasappa S, Monto Mani

Mani Koshy and Ganesh - Sustainability and Human Settlements Sage Publications,Current Literature,Current Literature,Current Literature

ST 203 (AUG) 3:0

Design, Technology and Sustainability

The course is open to students with a basic degree in engineering, science or architecture. This is a typical ‘learning-by-doing’ course in which students (from diverse disciplinary backgrounds) take up a topic of their interest and perform a rigorous exercise to thoroughly understand, evaluate, define and forecast sustainability attributed to their chosen topic. The interactive sessions start with a debate on development, covering its definitions, traditional and modern interpretations, dimensions, underlying premise and indicators.A comprehensive morphology-based understanding of technology/design and the detailed morphological analysis of each design/technology chosen for study provides the basis for subsequent development of the technology/design-integrated systems model. To begin with, the process of developing the systems model facilitates identification of first and second (dependent) order stakeholders linked across the morphology of the technology/design and life-cycle phases. This subsequently unfolds into a comprehensive multi-stakeholder sustainability perspective and permits traceability of sustainability indicators/impacts across various stakeholders and geographies. An emphasis is placed on defining sustainability (relevant and unique to individual projects) and identification of appropriate indicators. Amidst the diversity of individual projects dealt with in the course, a significant share of the 17 Sustainable Development Goals (SDGs) are discerned from a multidimensional viewpoint to consequently arrive at sustainability indicators and identification of possible technology/design-based interventions to aid/infuse/improve sustainability within the system.Besides covering the fundamental mandate of SDG-4: ‘Ensure inclusive and quality education for all and promote lifelong learning’, the course encompasses a much wider systems-thinking perspective on sustainability in all its multifaceted dimensions including social, environmental and economical. The feasibility, opportunities, challenges and limitations in achieving sustainability are also addressed.

Monto Mani

Mani Koshy and Ganesh 2005 - Sustainability and Human Settlements - Sage Publications New Delhi and London,Elliott JA 2002 - An Introduction to Sustainable Development - Routledge New York.,Bell and Morse 2008 - Sustainability Indicators: Measuring the Immeasurable - Earthscan Publications London,Meadows DH 2008 - Thinking in Systems - A Primer - Chelsea Green Publishing Company Vermont

ST 214 (AUG) 3:0

Mathematical Analysis of Experimental Data

Instrument characteristics for popular variables like length,pressure, temperature,velocity, force,density and torque.Systematic and random errors, calibration science and corrections at different scales of instrument,dimensional analysis leading to functionalities,critical and non-critical variables governing the process.Uncertainty analysis and curve fitting.Probability theory,sampling data, confidence levels,distribution of errors, Measurement Variability and Error;controlling and minimizing variabillity,replication,randomization, blocking and controls.Single factor experiments,randomized blocks,Latin square designs, Mathematical data analysis of data distribution,normal and t-distribution confidence interval and hypothesis testing Simple and multiple linear regressions.Mathematical analysis of experimental data from problems in fluid flow, heat transfer and combustion.

Dasappa S, Punit Singh, Lakshminarayana Rao M P

1.Enest O Doebelin,Engineering Experimentaton,McGraw-Hill International,2.G.Beckkwith and Lewis.N.Buck, Mechanical measurements,3.Box,G.E.P.,Hunter,W.G.,and Hunter,J.S.(1978),Statistics for experimenters:An Introduction to Design, Data Analysis,and Model Building, John Wiley & sons.Inc.ISBN:0-471-09315-7 4.Jack Philip Holman, Experimental methods for engineers,(2011),McGraw-HIll Series in Mechanical Engineering, Eight Edition

ST 201 (JAN) 3:0

Thermochemical and biological energy recovery from biomass

Biomass and its properties relevant for conversion processes. Thermochemical energy conversion processes and devices – stoves, combustors and gasifiers for heat, power and co-generation applications. Biological conversion techniques, processes and reactors. Efficiency, emissions. performance of end use devices and resource recovery options.

Dasappa S

Borman, G.L. and Ragland, K.W., Combustion Engineering, McGraw-Hill International Editions, Mechanical engineering series,. HS Mukunda, Understanding clean energy and fuels from biomass, Wiley India,Relevant papers from current literature.

ST 207 (JAN) 3:0

Alternate Fuels for Reciprocating Engines

Internal combustion engine classification, operating cycles, performance of spark ignition and compression ignition engines. Properties of various liquid and gaseous fuels. Combustion characteristics and performance of these fuels in engines – power output, efficiency and emissions

Dasappa S

Heywood, J., Internal Combustion Engine Fundamentals, McGraw Hill Publication,Journal papers – SAE,IMechE – journal of power and energy, Automobile Engineering,Current literature

ST 206 (JAN) 2:1

Environmental and Natural Resources Management

Principles of environmental management, principles of ecology, environment and environmental management, policies and legal aspect of environmental management, overview of environmental impact assessment (EIA). Preparation and review of environmental impact assessment report, environmental audit, life cycle assessment as EM Tool. Environmental management systems standards: ISO 14000 (EMS). Related issues in environmental management, environmental design and environmental economics.

Ramachandra TV

Kulkarni, V., and Ramachandra, T.V., Environmental Management, Capital Publishers, New Delhi, 2006,Lo, C.P., and Yeung, A.K.W., Concepts and Techniques of GIS, Prentice Hall of India Private Limited, New Delhi, 2002,. Kanholm, J., EMS Manual, 21 Procedures and Forms, AQA Press, USA, 2000,Holling, C.S., Adaptive Environmental Assessment and Management, John Willey & Sons, New York, 1987,Meadows, D.H., Meadows, D.L., and Randers, J., Beyond the Limits – Global Collapse or Sustainable Future, Earth Scan Publications Limited, London, 1992.

ST 209 (JAN) 2:0

Society and Technology

Understanding of technology for engineers, societal perspectives of technology, bridging the gap in understanding, overcoming conflicts in embedding technology in society, communicating technology, engaging in conversations and dialogue that help embed technology, planning sustainability into communicating technology, understanding existing perspectives of sustainability, merging it with the technical perspectives of sustainability, evolving communication that works for sustainable technologies, writing short texts and messages, peer group testing.

Anjula Gurtoo

Alley, M., The Craft of Scientific Presentations, Springer-Verlag, New York, Inc., 2003,Changing the Conversation: Messages for Improving Public Understanding of Engineering. Committee on Public Understanding of Engineering Messages. National Academy of Engineering. The National Academies Press, Washington,D.C, www.nap.edu , 2008,Diamond, J., Guns, Germs and Steel, W.W. Norton, 1997,Felt, U., The social and cultural tailoring of scientific knowledge in the public space, in M.E. GONCALVES (ed), Cultura cientifica e participaçao pública (Lisboa: Bertrand), 1999.,Ramakrishnan, P.S., Ecology and Sustainable Development – Working with knowledge systems, National Book trust, India, 2001

ST 213 (JAN) 3:0

Turbo machines in Renewable Energy

The objectives of the course is to refine turbo machinery designs in challenging operating conditions imposed by renewable energy sources characterized by variability(input/outputsides)and low intensity/enthalpy levels.concepts include Euler theory,velocity traingles,dimensional analysis,meanline/streamline theory,loss models,performance estimation,Cordier/nsds diagrams and others.Practical design approach from theory and experimental modules for incompressible fluids(hydro turbines, wind turbines,and liquid pumps)and compressible fluids (air,steam,and new working fluids for solar thermal and waste heat sources)Radial,diagonal and axial flow turbo machines with impulse and reaction physics.Discussion on innovative and unconventional turbo machines.

Punit Singh

1.DixonS.L and HallC.A,'Fluid Mechanics and Thermo Dynamics of Turbomachinery', 6th Edition,Elsevier,publication 2010,2.Neschleba M,'Hydraulic turbines-Their design and equipment', Atria Prage,1957,3.StepanoffA.J,'Centrifugal and Axial Flow Pumps,JohnWiley & Sons,Inc.,1957,4.Horlock J.H,'Axial Flow Compressors and Axial Flow Turbines,Fluid Mechanics and Thermodynamics',Butterworths,1958,5.Watson N and JanotaM.S, 'Turbocharging the Internal Combustion Engine',The Macmillan Press,1982 6.Balje O.E,'Turbo Machines-A guide to Design,Selection and Theory',John Willey & Sons 1981

Centre for Earth Sciences

M Tech Programme in Earth Science
Duration: 2 years: 64 Credits
Hard Core: 24 Credits (All courses are mandatory)
ES 201 2:1 Introduction to Earth System Science
ES 202 3:0 Geodynamics
ES 203 2:1 Introduction to Petrology
ES 204 3:0 Origin and Evolution of Earth
ES 205 3:0 Mathematics for Geophysicists
ES 206 3:0 Topics in Geophysics
ES 207 0:3 Earth Science Laboratories
ES 215 3:0 Introduction to Chemical Oceanography

Project: 25 Credits
Electives: 15 Credits of which at least 9 credits must be from among the group electives listed below.
ES 208 3:0 Mantle Convection
ES 209 3:0 Biogeochemistry
ES 210 3:0 Tectonics and Crustal Evolution
ES 211 3:0 Applied Petrology
ES 212 3:0 Fluid dynamics of planetary interiors
ES 213 3:0 Isotope Geochemistry
ES 214 3:0 Topics on stratigraphy and geochronology
CE 247N 3:0 Remote Sensing and GIS for Water Resources & Environmental Engineering

ES 401 (AUG) 3:0

Natural Hazards and Their Mitigation

Kusala Rajendran

~C.M.R.~The solid earth: An Introduction to Global Geophysics~Cambridge University Press~2005.

ES (AUG) 3:0

Advanced Chemical Oceanography

Sambuddha Misra

ES 204 (AUG) 3:0

Origin and Evolution of the Earth

Big Bang; origin of elements; early Solar System objects; bulk Earth composition; comparison of Earth and other Solar System objects; core-mantle differentiation; composition of the terrestrial mantle; mantle melting and geochemical variability of magmas; major, trace element and radiogenic isotope geochemistry; redox evolution of the mantle; evolution of the atmosphere and biosphere.

Ramananda Chakrabarti

Dickin,A. P.,Radiogenic Isotope Geology,Cambridge University Press,1995

ES 203 (AUG) 3:0

Introduction to Petrology

Theory: Rock forming minerals, textures of Igneous, metamorphic and sedimentary rocks, Micro-textures and reactions, using petrological datasets, rock types and tectonic settings, geothermometry and geobarometry, isochemical phase diagrams and its interpretations, linking petrology to geochronology, Geology of southern India and applications of petrology.

Sajeev Krishnan

Vernon R.H.,A practical guide to Rock Microstructure,Cambridge University Press,2004.,Deer

ES 201 (AUG) 2:1

Introduction to Earth System Science

Role of geology in understanding the Earth system processes. Composition of Lithosphere, Atmosphere and Biosphere. Earth surface processes and its consequences, earth as a dynamic planet. Planetary bodies and formation of universe. Early atmosphere, evolution of atmosphere through time, evolution of hydrosphere and general circulation of ocean through time. Long and short term history of cryosphere, fossilization, reconstruction of geologic time. Geochemic origin of life, RNA world, Miller Urey Experiment, Evolution affecting Biosphere, Great oxygenation Event (GOE), Paleobiology: Microfossil chemistry. Indian climate present day and past, Global paleoclimatic record, Paleomonsoon record and the role of tectonics.

Practical:

Project on the model of real-world ecosystems in order to understand how biotic and abiotic factors interact and to see how one type of ecosystem impacts other ecosystems

Prosenjit Ghosh

Merrits,D.,Dewet,A.,and Menking

ES 208 (AUG) 3:0

Mantle Convection

Plate tectonics and mantle convection, Constraining mantle flow from seismic tomography, Maxwell viscoelastic material, Spherical harmonics, Mantle viscosity, Creep mechanisms, Governing equations, Constraints of mantle flow modeling: geoid and dynamic topography, Thermal evolution of the Earth, Convection in other planets.

Attreyee Ghosh

Schubert,G.,Turcotte,D.,and Olson

ES 202 (AUG) 3:0

Geodynamics

Introduction to processes shaping the earth; developing chronological constraints.Reference frames and map projections, shape of the earth, Earth’s gravity field, geodesy, isostasy. Earth’s magnetic field, paleomagnetism, geomagnetic reversals.Plate tectonics, evolution of landforms and global seismicity. Earthquake types and quantification, interpreting seismograms, seismic waves and earth’s interior, earthquake source characterization, earthquake and faulting processes; types of faults and relation to stress fields, moment tensors and earthquake focal mechanisms.Effects of earthquakes, earthquakes in Indian context, Structure of the Earth’s interior- density, seismic velocity, pressure and temperature.Lab and field components: Handling earthquake recorders and data acquisition, Seismic Analysis Code and GMT for analyzing and representing global seismicity data.

Kusala Rajendran

Fowler, C.M.R., The solid earth: An Introduction to Global Geophysics, Cambridge University Press, 2005.,Turcotte, D., and Schubert, G., Geodynamics, Cambridge University Press, 2nd edition, 2001.,Turcotte, D., and Schubert, G., Geodynamics, Cambridge University Press, 2nd edition, 2001.

ES 205 (AUG) 3:0

Mathematics for Geophysicists

Vector fields: basic vector algebra, line, surface and volume integrals, potential, conservative fields, gradient, divergence, curl, circulation, Stokes's theorem, Gauss's theorem, applications in fluid mechanics and electromagnetism, Kelvin's theorem, Helmholtz's theorem. Linear algebra: Matrices, operations, eigen components, systems of linear differential equations, examples. Partial differential equations: The diffusion equation, wave equation, Laplace's equation, Poisson's equation, similarity solutions, numerical solutions (simple examples with MATLAB), series solutions, spherical harmonic expansions. Dimensional analysis: Pi theorem, similarity, nondimensional formulation of geophysical problems, examples.

Binod Sreenivasan

Riley,K.F.,Hobson,M.P.,and Bence

ES 214 (JAN) 3:0

Topics in stratigraphy and geochronology

C-S-Sr isotope stratigraphy, time-series chemostratigraphic correlation, time-series Litho stratigraphic correlation, Biostraigraphic correlation, Magnetostratigraphy, Non-traditional isotope stratigraphy, Stratigraphy on Mars,Zircon texture, morphology, zoning, Zircon as an equilibrium mineral, U-Pb dating of Zircon, REE in zircon, Th/U ratio in Zircon, Hf in zircon, U-Pb dating methods, plotting and interpretation of ages, connecting age to tectonics

Prosenjit Ghosh, Sajeev Krishnan

Grastein,Ogg and Schmitz,The Geologic Time Scale 2012 2-Volume Set,1st Edition,ISBN: 9780444594488

ES 206 (JAN) 3:0

Topics in Geophysics

Earth's internal structure: composition vs mechanical properties, Geoid, GIA and viscosity, Stress and Strain from seismology perspective, Theory of Elasticity, Wave mechanics, Seismic tomography, Earth's free oscillations, Phase transformations within the Earth, Introduction to mineral physics, Spherical harmonics, Heat: conductive, convective and radioactive heat flow, Heat flow in oceans and continents, Half space vs plate cooling models, Convection within mantle and core, Structure of mid-oceanic ridge system, Strength of continental lithosphere

Attreyee Ghosh

Fowler,C.M.R.,The Solid Earth: An Introduction to Global Geophysics,2nd edition,Cambridge University Press

ES 207 (JAN) 0:3

Earth Science Laboratory

Geochemical techniques; mineral chemical techniques; sedimentology techniques; computational techniques.

Prosenjit Ghosh

Reed,S.J.B.,Electron Microprobe Analysis and Scanning Electron Microscopy in Geology,2nd Edition,Cambridge University Press

ES 209 (JAN) 3:0

Biogeochemistry

Geochemistry of the Earth, Big bang, Nucleosynthesis, origin of solar system, electronic structure of atoms, periodic tables, chemical bonds. Crystals, Ionic substitution, Isotope geo-chronometer, chemical reactions and stability of minerals, acids and bases, salts and their ions. Thermodynamics, mineral stability, clay minerals, carbonate minerals, oxidation-reduction reaction, isotope fractionation, mixing and dilution, rate of chemical processes, chemical weathering, chemical composition of surface water, stable isotope geochemistry Carbon cycling, other geochemical cycle (-P-N-S), ,Metabolism and geochemistry, Mineral-Microbe-Interaction, Bioweathering, Biomineralization, Environmental metagenomics, Economic Biogeochemistry.

Prosenjit Ghosh

Schlesinger,W.H.,Biogeochemistry: An analysis of Global Change,Academic Press,1997

ES 210 (JAN) 3:0

Tectonics and Crustal Evolution

Introduction to the theory of plate tectonics, application to understanding the structure, evolution and dynamic processes of the earth. Plate motions on flat and spherical earth, evolution and stability of triple junctions, plate driving forces, seismicity and volcanism as a consequence of plate motions, evolution of landforms, mountain building, paleomagnetism and reconstruction of continental masses, plate tectonics through time. Evolution of Indian plate through time, dynamics of its plate boundaries; earthquakes as a tool to understand processes along plate boundaries.

Kusala Rajendran

Philip Keary, Keith A. Kelpeis and Frederick J. Vine, Global tectonics, Wiley-Blackwell, Third edition.,Fowler, C.M.R., The Solid Earth: An Introduction to Global Geophysics, Cambridge University Press, Second edition,Fowler, C.M.R., The Solid Earth: An Introduction to Global Geophysics, Cambridge University Press, Second edition

ES 212 (JAN) 3:0

Fluid dynamics of planetary interiors

Basic fluid dynamics - Navier-Stokes equation, vorticity equation, Kelvin's circulation theorem, energy and dissipation, helicity.

Rotation - Coriolis force, linear inertial waves, formation of Taylor columns, geostrophy, quasistrophic approximation.

Stratification - Gravity waves, effect of rotation, Braginsky's theory of stratified outer core of the Earth.

Magnetic fields - Magnetohydrodynamic (MHD) equations, Lorentz force, low and high magnetic Reynolds number, Alfven waves, Magnetic-Coriolis (MC) waves, Rayleigh Benard convection with magnetic field and rotation, MHD of planetary cores.

Turbulence - Richardson's cascade, overview of classical theories, 2D turbulence, turbulence under moderate and rapid rotation, MHD turbulence, different length scales in planetary core turbulence.

Binod Sreenivasan

Davidson,P.A.,Turbulence in rotating,stratified and electrically conducting fluids,Cambridge University Press

ES 213 (JAN) 3:0

Isotope Geochemistry

Nuclear systematics; decay mode of radionuclides; radioactive decay; Rb-Sr, Sm-Nd, Lu-Hf, Re-Os and U-Th-Pb systematics, U series disequilibrium, stable isotope fractionation, early Solar System processes, crust-mantle processes, aquatic processes, selected mass spectrometry techniques.

Ramananda Chakrabarti

Alan P. Dickin,Radiogenic Isotope Geology,Cambridge University Press,1995,Gunter Faure and Teresa M. Mensing

ES 215 (JAN) 3:0

Introduction to Chemical Oceanography

Sambuddha Misra

ES 299 (JAN) 0:25

Dissertation Project

Division of Interdisciplinary Research

Preface

The Division of Interdisciplinary Research consists of the Biosystems Science & Engineering, Department of Computational and Data Sciences, Centre for Contemporary Studies, Interdisciplinary Centre for Energy Research, Interdisciplinary Centre for Water Research, Centre for Nano Science and Engineering, Centre for Infrastructure, Sustainable Transportation and Urban Planning, Department of Management Studies, Robert Bosch Centre for Cyber Physical Systems and Supercomputer Education and Research Centre. The courses offered in the different departments of the Division have been reorganized after review and revision, and have been grouped department wise. These are identified by the following code.

BE	Biosystems Science & Engineering
CP	Cyber Physics
ER	Energy Research
DS	Computational and Data Sciences
MS	Management Studies
NE	Nano Science and Engineering
UP	Infrastructure,Sustainable Transportation and Urban Planning

The first two digits of the course number have the departmental code as the prefix. All the Departments/ Centres of the Division provide facilities for research work leading to the degrees of M Tech, M Tech (Research) and PhD. There are specific requirements for completing a Research Training Programme for students registered for research at the Institute. For individual requirements, students are advised to consult the Departmental Curriculum Committee. The M Tech Degree Programmes are offered in Centre for Nano Science and Engineering, Department of Computational and Data Sciences. Department of Civil Engg and CiSTUP jointly offer an M Tech Programme in Transportation Engineering. Department of Management Studies offers a Master of Management. Most of the courses are offered by the faculty members of the Division, but in certain areas, instruction by specialists in the field and experts from industries are also arranged.

Prof. G Rangarajan
Chairman
Division of Interdisciplinary Research

INTERDISCIPLINARY PROGRAM - BioSystems Science and Engg

BE 210 (AUG) 3:0

Drug Delivery: Principles and Applications

This course introduces concepts of drug delivery to meet medical challenges. The course is designed to be modular, with each module focusing on the following topics: Diffusion and permeation of drugs in biological systems; Pharmacokinetics and pharmacodynamics; Challenges and strategies for various drug delivery routes; Drug-delivery systems: polymer-drug conjugates, matrix-based systems, reservoir and erodible systems; Responsive and targeted delivery systems; Nanotoxicology and Translational regulatory pathways. Students will also be asked to work on a group-project to propose a drug-delivery application for an existing medical need.

Rachit Agarwal

1. Drug Delivery: Engineering Principles for Drug Therapy,W. Mark Saltzman,Oxford University Press,2001~2. Drug Delivery: Fundamentals and Applications,Anya M. Hillery and Kinam Park

BE 203 (AUG) 0:1

Bioengineering Practicum 1

Bioengineering Practicum 1 is a compulsory course for all BSSE PhD Students in their first Semester of their PhD programme. It is not open for students from other departments.

The course provides bioengineering laboratory experience to enable the student do practical work on a particular field of specialization by working in the laboratories of the thesis advisers. The student is expected to learn the experimental techniques and practical methods pertaining to the research topic undertaken. The evaluation will be based on oral presentation to the BSSE faculty.

In this course, the students are expected to work in the laboratory of the adviser(s) and learn the computational and/or experimental techniques required in their research. Generally, the adviser(s) and the student have a general research topic in mind and use that to decide the techniques to be learnt. The purpose of this course is to enable the student to get familiar with the research topic and take the first steps in beginning thesis research.The students are advised to take the initiative to thoroughly understand all the related material of each and every technique they are supposed to learn.

Ananthasuresh G K, Rachit Agarwal

BE 204 (AUG) 0:2

Bioengineering Practicum 2

Bioengineering Practicum 2 is a compulsory course for all BSSE PhD Students in their first Semester of their PhD programme. It is not open for students from other departments.

The course provides bioengineering laboratory experience to enable the student do practical work on a particular field of specialization by working in the laboratories of the thesis advisers. The student is expected to learn the experimental techniques and practical methods pertaining to the research topic undertaken. The evaluation will be based on oral presentation to the BSSE faculty.

In this course, the students are expected to work in the laboratory of the adviser(s) and learn the computational and/or experimental techniques required in their research. Generally, the adviser(s) and the student have a general research topic in mind and use that to decide the techniques to be learnt. The purpose of this course is to enable the student to get familiar with the research topic and take the first steps in beginning thesis research.The students are advised to take the initiative to thoroughly understand all the related material of each and every technique they are supposed to learn.

Ananthasuresh G K, Rachit Agarwal

BE 206 (AUG) 3:0

Biology for Engineers

The course provides an introduction to fundamental concepts in Biology for PhD students with little to no knowledge of Biology past 10th or 12th standard school curriculum. The course will aim to provide a basic introduction to modern biology, while covering the following topics: evolution, biomolecules, fundamentals of biochemistry, protein structure and function, basic molecular biology, genetics, and an introduction to the cellular architecture. A combination of theoretical concepts and basic experimental methodologies in biology will be discussed. In addition, an introduction to plant and human physiology will also be provided, which includes lectures on classification of tissues, basic human anatomy, and an in-depth discussion on neurophysiology. The concepts covered here will aid in the skill development required to study diverse problems in bioengineering.

Aditya Murthy, Siddharth Jhunjhunwala, Vaishnavi Ananthanarayanan

B. Alberts,A. Johnson,J. Lewis,M. Raff,K. Roberts

BE 208 (JAN) 3:0

Fundamentals of Bioengineering

This course will aim to introduce concepts in the interdisciplinary areas of bioengineering, biomedical engineering and biotechnology. The course is designed to be modular, with each module focusing on one of the following topics: introduction to mathematics and biology; polymer engineering; transport phenomena through polymeric matrices and its applications in drug delivery; biological and immune responses to polymeric implants; principles of tissue engineering; computational approaches to study biological phenomena; and bioprocess engineering that includes an introduction enzyme kinetics, metabolic pathways and bioreactors. Each module will include three didactic lectures (1.5 hours each) followed by one class discussing a recent journal article related to that module (1.5 hours).

Siddharth Jhunjhunwala

1. Biomedical Engineering: Bridging Medicine and Technology,W. Mark Saltzman,Cambridge University Press,2009,Introduction in biomedical engineering

BE 207 (JAN) 3:0

Mathematical Methods for Bioengineers

Narendra M Dixit

BE 203 (JAN) 0:1
Bioengineering Practicum 1

Ananthasuresh G K

BE 204 (JAN) 0:2
Bioengineering Practicum 2

Ananthasuresh G K

BE 208 (MAY) 3:0
Fundamentals of Bioengineering

Centre for Nanoscience and Engineering

M Tech Degree Programme
Centre for Nano science and Engineering
Duration: 2 years

Departmental Core 28 credits

Course	Credits	Title
NE 215	3:0	Applied Solid State Physics
NE 241	3:0	Materials Synthesis: Quantum Dots to Bulk Crystals
NE 205	3:0	Semiconductor Devices and IC Technology
NE 213/E7 213	3:0	Introduction to Photonics
NE 211	3:0	Micro/Nano Mechanics
NE 202	1:1	Micro and Nano Fabrication
NE 201	2:1	Micro and Nano Characterization
NE 221	2:1	Advanced MEMS Packaging
NE 222	3:0	Micromachining for MEMS Technology
NE 100	1:0	Technical Writing and Presentation
NE 101	1:0	Entrepreneurship, Ethics and Societal Impact

Project

NE 299	**0:27**	**Project Work**
	0:03	**May-July**
	0:09	**August–December**
	0:15	**January June**

Electives: The balance of 9 credits to make up the minimum of 64 credits required to complete the M Tech Programme at CeNSE. Electives from within/outside the department can be taken with the approval of the DCC/Faculty advisor.

NE 223 (AUG) 2:1

Analog Circuits and Embedded System for Sensors

Basic Circuit Analysis and Passive Components; Introduction to semiconductor devices and circuits involving Diodes, BJT, MOSFET and JFET; Opamp circuits: Transimpedance amplifier, Instrumentation amplifier, Comparator, Precision DMM application; Tradeoffs between power, noise, settling time and cost; Survey of sensors and their datasheets; Filters and Oscillators; Introduction to digital logic, State Machines, Digital IO, 555 timer, Latch, Flip-flops, Divide by N; Microcontroller programming; Communication protocols for sensor interfacing

Saurabh Arun Chandorkar

Paul Horowitz, Winfield Hill, “Art of Electronics”, Cambridge University Press, 3rd Edition, 2015,,,J. Edward Carryer, Matthew Ohline and Thomas Kenny, “Introduction to Mechatronic Design”, Pearson Education India, 1st International edition, 2012,Jeremy Blum, "Exploring Arduino: Tools and Techniques for Engineering Wizardry", Wiley, 2013),1st year undergraduate level Basic Circuits course,,1st year undergraduate level Basic Programming course

NE 250 (AUG) 1:0

Entrepreneurship, Ethics and Societal Impact

This course is intended to give an exposure to issues involved in translating the technologies from lab to the field. Various steps and issues involved in productization and business development will be clarified, drawing from experiences of successful entrepreneurs in high technology areas. The intricate relationship between technology, society and ethics will also be addressed with illustrations from people involved in working with the grass root levels of the society.

Navakanta Bhat

Lecture notes,-,-

NE 241 (AUG) 3:0

Material Synthesis: Quantum Dots To Bulk Crystals

All device fabrication is preceded by material synthesis which in turn determines material microstructure,

properties and device performance. The aim of this course is to introduce the student to the principles that help control growth. Crystallography ; Surfaces and Interfaces; Thermodynamics, Kinetics, and Mechanisms of Nucleation and Growth of Crystals ; Applications to growth from solutions, melts and vapors (Chemical vapor deposition an Physical vapor deposition methods); Stress effects in film growth

Srinivasan Raghavan

Ivan V. Markov, Crystal growth for Beginners, Fundamentals of Nucleation, Crystal Growth and Epitaxy, World Scientific, 1998.(548.5,N96),L.B.Freund, S.Suresh, Thin Film Materials – Stress, Defect Formation and Surface Evolution, Cambridge University Press, 2003. (621.38152 PO36),Milton Ohring, Material Science of Thin Films, Academic Press,-,-

NE 201 (AUG) 2:1

Micro and Nano Characterization Methods

This course provides training in the use of various device and material characterization techniques. Optical characterization: optical microscopy, thin film measurement, ellipsometry, and Raman spectroscopy; Electrical characterization: Noise in electrical measurements, Resistivity with 2- probe, 4-probe and van der Pauw technique, Hall mobility, DC I-V and High frequency C-V characterization; Mechanical characterization: Laser Doppler vibrometry, Scanning acoustic microscopy, Optical profilometry, and Micro UTM; Material characterization: Scanning electron microscopy, Atomic force microscopy, XRD, and Focused ion beam machining.

Manoj Varma, Akshay K Naik

Lecture notes hands-on training manuals,Hands-on training manuals,Handouts on detailed process flows and device characterization schedule

NE 215 (AUG) 3:0

Applied Solid State Physics

This course is intended to build a basic understanding of solid state science, on which much of modern device technology is built, and therefore includes elementary quantum mechanics. Review of Quantum Mechanics and solid state physics, Solution of Schrodinger equation for band structure, crystal potentials leading to crystal structure, reciprocal lattice, structure-property correlation, Crystal structures and defects, X-ray diffraction, lattice dynamics, Quantum mechanics and statistical mechanics, thermal properties, electrons in metals, semiconductors and insulators, magnetic properties, dielectric properties, confinement effects

Shivashankar S A, Akshay K Naik

Stephen Elliott, Physics and Chemistry of Solids John Wiley, 1998,S. M Lindsay, Introduction to Nanoscience, Oxford (2010),-,-,-

NE 202 (AUG) 0:1

Micro AND Nano Fabrication

This course is designed to give training in device processing at the cleanroom facility. Four specific modules will be covered to realize four different devices i) p-n junction diode, ii) MOS capacitor iii) MEMS Cantilever iv) Microfluidic channel.

Shankar Kumar Selvaraja, Sushobhan Avasthi

Handouts on detailed process flows and device characterization schedule,Marc J. Madou,Fundamentals of Microfabrication and Nanotechnology,CRC press,ISBN 9780849331800

NE 205 (AUG) 3:0

Semiconductor Devices and Integrated Circuit Technology

This is a foundation level course in the area of electronic device technology. Band structure and carrier statistics, Intrinsic and extrinsic semiconductor, Carrier transport, p-n junction, Metal-semiconductor junction, Bipolar Junction Transistor, Heterojunction, MOS capacitor, Capacitance-Voltage characteristics, MOSFET, JEFET, Current-Voltage characteristics, Light Emitting Diode, Photodiode, Photovoltaics, Charge Coupled Device Integrated circuit processing, Oxidation, Ion implantation, Annealing, Diffusion, Wet etching and dry plasma etching, Physical vapour deposition, Chemical vapour deposition, Atomic layer deposition, Photolithography, Electron beam lithography, Chemical mechanical polishing, Electroplating, CMOS process integration, Moore’s law, CMOS technology scaling, Short channel effects, Introduction to Technology CAD, Device and Process simulation and modeling

Digbijoy N Nath

Streetman and Banerjee,Solid State Electronic Devices,Prentice-Hall,-,-

NE 231 (AUG) 3:0

Microfluidics

This is a foundation course discussing various phenomena related to fluids and fluid-interfaces at micro-nano scale. This is a pre-requisite for advanced courses and research work related to micro-nano fluidics.Transport in fluids, equations of change, flow at micro-scale, hydraulic circuit analysis, passive scalar transport, potential fluid flow, stokes flow Electrostatics and electrodynamics, electroosmosis,electrical double layer (EDL), zeta potential, species and charge transport, particle electrophoresis,AC electrokinetics Surface tension, hysteresis and elasticity of triple line, wetting and long range forces, hydrodynamics of interfaces, surfactants, special interfaces Suspensions, rheology,nanofluidics, thick-EDL systems, DNA transport and analysis

Prosenjit Sen

Brian J. Kirby, Micro- and Nanoscale Fluid Mechanics, Cambridge University Press,P.-G. de Gennes, F. Brochard-Wyart, and D. Quere, Capillarity and Wetting Phenomena, Springer,R. F. Probstein, Physicochemical Hydrodynamics, Wiley Inter-Science,-,-

NE 213 (AUG) 3:0

Introduction to Photonics

This is a foundation level optics course which intends to prepare students to pursue advanced topics in more specialized areas of optics such as biophotonics, nanophotonics, non-linear optics etc. Classical and quantum descriptions of light, diffraction, interference, polarization. Fourier optics, holography, imaging, anisotropic materials, optical modulation, waveguides and fiber optics, coherence and lasers, plasmonics.

Manoj Varma, Ambarish Ghosh

Bahaa Saleh and Malvin Teich, Fundamentals of Photonics, Wiley and Son (1991) Hecht E, Optics. Addison Wesley, 2001,-,-,-,-

NE 203 (AUG) 3:0

Advanced micro- and nanofabrication technology and process

Introduction and overview of micro and nano fabrication technology. Safety and contamination issues in a cleanroom. Overview of cleanroom hazards. Basic process flow structuring. Wafer type selection and cleaning methods. Additive fabrication processes. Material deposition methods. Overview of physical vapour deposition methods (thermal, e-beam, molecular beam evaporation) and chemical vapour deposition methods (PE-CVD, MOCVD, CBE, ALD). Pulsed laser deposition (PLD), pulsed electron deposition (PED). Doping: diffusion and ion implant techniques. Optical lithography fundamentals, contact lithography, stepper/canner lithography, holographic lithography, direct-laser writing. Lithography enhancement methods and lithography modelling. Non-optical lithography; E-beam lithography, ion beam patterning, bottom-up patterning techniques. Etching process: dry and wet. Wet etch fundamentals, isotropic, directional and anisotropic processes. Dry etching process fundamentals, plasma assisted etch process, Deep Reactive Ion Etching (DRIE), Through Silicon Vias (TSV). Isotropic release etch. Chemical-mechanical polishing (CMP), lapping and polishing. Packaging and assembly, protective encapsulating materials and their deposition. Wafer dicing, scribing and cleaving. Mechanical scribing and laser scribing, Wafer bonding, die-bonding. Wire bonding, die-bonding. Chip-mounting techniques.

Shankar Kumar Selvaraja / Sushobhan Avasthi

Marc J. Madou,Fundamentals of Microfabrication and Nanotechnology,CRC press,ISBN 9780849331800,VLSI Fabrication Principles Silicon Gallium Arsenide 2nd Edition

NE 312 (AUG) 3:0

Nonlinear and Ultrafast Photonics

This is an intermediate level optics course which builds on the background provided in “Introduction to photonics” offered in our department. Owing to the extensive use of nonlinear optical phenomena and Ultrafast lasers in various fields, we believe a good understanding of these principles is essential for students in all science and engineering disciplines, in particular students involved in the area of Photonics, RF and Microwave systems, Optical Instrumentation and Lightwave (Fiber-optic) Communications. In addition, this course intends to prepare students to pursue advanced topics in more specialized areas of optics such as Biomedical Imaging, Quantum optics, Intense field phenomena etc.

Supradeepa V R

Robert W. Boyd, Nonlinear Optics, Elsevier (2003),Govind P. Agrawal, Nonlinear Fiber Optics, Elsevier (2007),Andrew M Weiner, Ultrafast Optics, Wiley (2008),Miscellaneous Research Articles and Reviews.,-

NE 222 (AUG) 3:0

MEMS: Modeling, Design, and Implementation

This course discusses all aspects of MEMS technology – from modeling, design, fabrication, process integration, and final implementation. Modeling and design will cover blockset models of MEMS transducers, generally implemented in SIMULINK or MATLAB. Detailed multiphysics modeling may require COMSOL simulations. The course also covers MEMS specific micromachining concepts such asbulk micromachining, surface micromachining and related technologies, micromachining for high aspect ratio microstructures,glass and polymer micromachining, and wafer bonding technologies. Specific case studies covered include Pressure Sensors, Microphone, Accelerometers, Comb-drives for electrostatic actuation and sensing, and RF MEMS. Integration of micromachined mechanical devices with microelectronics circuits for complete implementation is also dicussed.

Rudra Pratap

G.K.Ananthasuresh,K.J.Vinoy,S. Gopalakrishnan,K.N.Bhat and V.K.Aatre. “Micro and Smart Systems- Technology and Modelling” John Wiley & Sons,Inc (2012)

NE 211 (JAN) 3:0

Micro/Nano Mechanics

This is a foundation level course in mechanics which will prepare students to pursue advanced studies related to mechanical phenomena at the micro and nano scales. Basics of continuum theory, continuum hypothesis, elasticity, thermoelasticity, fluid mechanics, heat conduction, electromagnetism, coupled thermal-elastic and electrostatic-elastic systems, MEMS and NEMS structures -- beams, plates, and membranes, scaling of mechanical properties and continuum limits, numerical methods for mechanical modelling, mechanics beyond continuum theory.

Akshay K Naik, Prosenjit Sen

John A. Palesko and David H. Bernstein, Modeling MEMS and NEMS, Chapman and Hall/CRC,-,-

NE 313 (JAN) 3:0

Lasers: Principles and Systems

This is an intermediate level optics course which builds on the background provided in “Introduction to photonics” offered in our department. Owing to the extensive use of lasers in various fields, we believe a good understanding of these principles is essential for students in all science and engineering disciplines.

Supradeepa V R

Anthony E. Siegman, Lasers, University Science Books (1986),OrazioSvelto, Principles of Lasers, Springer (2010),Miscellaneous Research Articles and Reviews.

NE 201 (JAN) 2:1

Micro and Nano Characterization Methods

This course provides training in the use of various device and material characterization techniques. Optical characterization: optical microscopy, thin film measurement, ellipsometry, and Raman spectroscopy; Electrical characterization: Noise in electrical measurements, Resistivity with 2- probe, 4-probe and van der Pauw technique, Hall mobility, DC I-V and High frequency C-V characterization; Mechanical characterization: Laser Doppler vibrometry, Scanning acoustic microscopy, Optical profilometry, and Micro UTM; Material characterization: Scanning electron microscopy, Atomic force microscopy, XRD, and Focused ion beam machining.

Manoj Varma, Akshay K Naik

Lecture notes and hands-on training manuals,-,-

NE 202 (JAN) 0:1

Micro AND Nano Fabrication

This course is designed to give training in device processing at the cleanroom facility. Four specific modules will be covered to realize four different devices i) p-n junction diode, ii) MOS capacitor iii) MEMS Cantilever iv) Microfluidic channel

Shankar Kumar Selvaraja, Sushobhan Avasthi

Handouts on detailed process flows and device characterization schedule,-,-

NE 200 (JAN) 2:0

Technical Writing and Presentation

This course is designed to help students learn to write their manuscripts,technical reports, and dissertations in a competent manner. The do's and dont's of the English language will be dealt with as a part of the course. Assignments will include writing on topics to a student's research interest, so that the course may benefit each students directly.

Shivashankar S A

The Elements of Style William Strunk Jr. and E.B. White 4th Edition Long man,Academic Writing Stephen Bailey 2nd Edition Routledge,The Elements of Technical Writing Gary Blake and Robert W Bly - Longman

NE 332 (JAN) 3:0

Physics and Mathematics of Molecular Sensing

This course presents a systematic view of the process of sensing molecules with emphasis on bio-sensing using solid state sensors. Molecules that need to be sensed, relevant molecular biology, current technologies for molecular sensing, modeling adsorption-desorption processes, transport of target molecules, noise in molecular recognition, proof-reading schemes, multi-channel sensing, comparison between in-vivo sensing circuits and solid state biosensors

Manoj Varma

Lecture notes and selected publications from recent literature. Familiarity with solution of ODEs and PDEs, knowledge of Matlab, Mathematica or an equivalent programming language, elementary probability theory,-,-

NE 310 (JAN) 3:0

Photonics technology: Materials and Devices

Optics fundamentals; ray optics, electromagnetic optics and guided wave optics, Light-matter interaction, optical materials; phases, bands and bonds, waveguides, wavelength selective filters, electrons and photons in semiconductors, photons in dielectric, Light-emitting diodes, optical amplifiers and Lasers, non-linear optics, Modulators, Film growth and deposition, defects and strain, III-V semiconductor device technology and processing, silicon photonics technology, photonic integrated circuit in telecommunication and sensors.

Shankar Kumar Selvaraja

Saleh, B. E. A., and M. C. Teich. Fundamentals of Photonics. New York, NY: Wiley, 1991.,T. Tamir, Topics in Applied Physics Volume 7: Integrated Optics, Springer-Verlag Berlin.,Haus, H. A. Waves and Fields in Optoelectronics. Englewood Cliffs, NJ: Prentice-Hall.,Research articles,,Handouts and Lecture

NE 221 (JAN) 2:1

Advanced MEMS Packaging

This course intends to prepare students to pursue advanced topics in more specialized areas of MEMS and Electronic packaging for various real time applications such as Aero space, Bio-medical, Automotive, commercial, RF and micro fluidics etc. MEMS – An Overview, Miniaturisation, MEMS and Microelectronics -3 levels of Packaging. Critical Issues viz., Interface, Testing & evaluation. Packaging Technologies like Wafer dicing, Bonding and Sealing. Design aspects and Process Flow, Materials for Packaging, Top down System Approach. Different types of Sealing Technologies like brazing, Electron Beam welding and Laser welding. Vacuum Packaging with Moisture Control. 3D Packaging examples. Bio Chips / Lab-on-a chip and micro fluidics, Various RF Packaging, Optical Packaging, Packaging for Aerospace applications. Advanced and Special Packaging techniques – Monolithic, Hybrid etc., Transduction and Special packaging requirements for Absolute, Gauge and differential Pressure measurements,Temperature measurements, Accelerometer and Gyro packaging techniques, Environmental Protection and safety aspects in MEMS Packaging. Reliability Analysis and FMECA. Media Compatibility Case Studies, Challenges/Opportunities/Research frontier.

Prosenjit Sen

Tai-Ran Hsu, MEMS PACKAGING, INSPEC, The Institution of Electrical Engineers, London,UK,2004,Tai-Ran Hsu, MEMS & MICRO SYSTEMS Design and Manufacture, Tata McGraw Hill, New Delhi,2002,John H Lau, Cheng Kuo Lee, C.S. Premchandran, Yu Aibin, Advanced MEMS Packaging, McGraw-Hill, 2010

NE 314 (JAN) 3:0

Semiconductor Opto-electronics and Photovoltaics

Sushobhan Avasthi, Digbijoy N Nath

NE 299 (JAN) 0:27

Dissertation Project

INTERDISCIPLINARY PROGRAM - ENERGY

ER 201 (AUG) 3:0

Renewable Energy Technologies

Energy is a critical component in the daily life of mankind. Historically, energy production technologies have shown a continual diversification depending on technological, social, economical, and even political impacts. In recent times, environmental and ecological issues have also significantly affected the energy usage patterns. Hence, renewable energy sources are occupying increasingly important part of the emerging energy mix. This course gives an introduction to key renewable energy technologies. Case studies will be discussed to emphasize the applications of renewable energy technologies. At the end of the course students should be able to identify where, how and why renewable energy technologies can be applied in practice.

Dasappa S, Pradip Dutta, Praveen C Ramamurthy

None,None,None

ER 202 (JAN) 2:1

Energy Conversion, Power Transmission and Distribution

Overview of primary and renewable energy sources, installed capacity and projected growth, applications, advantages and limitations. Energy conversion: Solar, wind, micro-hydro etc, system control requirements, grid connectivity issues. Recent advances in power transmission, introduction to EHV/UHV AC and DC transmission systems; present status and future growth. Design criteria for overhead transmission lines: general system design, methodology, components of HV transmission systems, types of conductors/accessories and bundle configurations, Transmission towers- calculations of clearances for power frequency, switching and lightning surges, right of way (ROW), earth wire/OPGW, selection of insulators for light, medium and heavy polluted areas, Up-gradation of existing transmission lines, Design considerations of HV Substations, Comparison of AIS, Hybrid-AIS and GIS, Insulation coordination for UHV systems, earthing and safety measures in UHV substations, Sub-station automation, power distribution, distribution reforms, SCADA.Laboratory experiments on concepts in generation of primary and renewable energy sources, Assignments involving computation/simulation of ground end electric and magnetic fields, technical visits to Industry/HV Substation.

Umanand L, Subba Reddy Basappa

None,None,None

CDS-Computer and Data Systems

Computational Science

Course Code	Course Name	Theory Credits	Practical Credits	Instructor	Year	Term
DS 211	Numerical Optimization	3	0	Atanu Kumar Mohanty, Phaneendra Kumar Yalavarthy	2018	August Session
DS 290	Modelling and Simulation	3	0	Soumyendu Raha	2018	August Session
DS 284	Numerical Linear Algebra	2	1	Murugesan Venkatapathi	2018	August Session
DS 301	Bioinformatics	2	0	Sekar K, Debnath Pal	2018	August Session
DS 288	Numerical Methods	3	0	Sashikumaar Ganesan	2018	August Session
DS 221	Introduction to Scalable Systems	3	1	Sathish S Vadhiyar, Yogesh L Simmhan	2018	August Session
DS 222	Machine Learning with Large Datasets	3	1	Partha Pratim Talukdar	2018	August Session
Course Code	**Course Name**	**Theory Credits**	**Practical Credits**	**Instructor**	**Year**	**Term**
DS 397	Topics in Embedded Computing	2	1	Nandy S K	2019	January Session
DS 289	Numerical Solution of Differential Equations	3	1	Atanu Kumar Mohanty	2019	January Session
DS 256	Scalable Systems for Data Science	3	1	Yogesh L Simmhan	2019	January Session
DS 295	Parallel Programming	3	1	Sathish S Vadhiyar	2019	January Session
DS 294	Data Analysis and Visualization	3	0	Phaneendra Kumar Yalavarthy, Anirban Chakraborty	2019	January Session
DS 299	Dissertation Project	0	28		2019	January Session
DS 260	Medical Imaging	3	0	Phaneendra Kumar Yalavarthy	2019	January Session
DS 255	System Virtualization	3	1	Lakshmi Jagarlamudi	2019	January Session
DS 265	Deep Learning for Computer Vision	3	1	Venkatesh Babu R	2019	January Session
DS 291	Finite Elements: Theory and Algorithms	3	1	Sashikumaar Ganesan	2019	January Session
Course Code	**Course Name**	**Theory Credits**	**Practical Credits**	**Instructor**	**Year**	**Term**
DS 323	Parallel Computing for Finite Element Methods	1	1	Sashikumaar Ganesan	2019	May Session

Computer and Data Systems

Course Code	Course Name	Theory Credits	Practical Credits	Instructor	Year	Term
DS 263	Video Analytics	3	1	Venkatesh Babu R, Anirban Chakraborty	2018	August Session

DS 221 (AUG) 3:1

Introduction to Scalable Systems

Architecture: computer organization, single-core optimizations including exploiting cache hierarchy and vectorization, parallel architectures including multi-core, shared memory, distributed memory and GPU architectures; Algorithms and Data Structures: algorithmic analysis, overview of trees and graphs, algorithmic strategies, concurrent data structures; Parallelization Principles: motivation, challenges, metrics, parallelization steps, data distribution, PRAM model; Parallel Programming Models and Languages: OpenMP, MPI, CUDA; Distributed Computing: Commodity cluster and cloud computing; Distributed Programming: MapReduce/Hadoop model.

Sathish S Vadhiyar

Consent from Advisor~Basic knowledge of system science~Basic data structures and programming~Basics of computer systems~Basic algorithms

DS 263 (AUG) 3:1

Video Analytics

Introduction to Digital Image and Video Processing, Background Modeling, Object Detection and Recognition, Local Feature Extraction, Biologically Inspired Vision, Object Classification, Categorization, Tracking, Activity Recognition, Anomaly Detection, Intrusion detection, Handling occlusion, scale and appearance changes.

Anirban Chakraborty

Image Processing,Probability,Computer Vision: Algorithms and Applications,by Rick Szeliski

CDS-Computational Science

DS 284 (AUG) 2:1

Numerical Linear Algebra

Introduction: Matrix and vector norms, arithmetic and computational complexity, floating point arithmetic. Matrix factorization and direct methods for solving linear systems: Gaussian elimination, LU factorization, Pivoting, Cholesky decomposition, QR factorization, Gram-Schmidt orthogonalization, Projections, Householder reflectors, Givens rotation, Singular Value Decomposition, Rank and matrix approximations, image compression using SVD, generalized Schur decomposition (QZ decomposition), Least squares and solution of linear systems and pseudoinverse, normal equations.Stability Analysis: conditioning of a problem, forward and backward stability of algorithms, perturbation analysis.Eigenvalue problems: Gershgorin theorem, Similarity transform, Eigenvalue & eigenvector computations, Power method, Schur decomposition, Jordan canonical form, QR iteration with & without shifts, Hessenberg transformation, Rayleigh quotient, Symmetric eigenvalue problem, Jacobi method, Divide and Conquer, Iterative methods: Computing the Singular Value Decomposition, solving linera systems (Jacobi, Gauss-Seidel and SOR), convergence of iterative algorithms, Krylov subspace methods (Lanczos, Arnoldi, MINRES, GMRES, Conjugate Gradient and QMR), Pre-conditioners, Approximating eigenvalues and eigenvectors.

Murugesan Venkatapathi

Basics of matrix algebra,Basic programming,Vectors and vector spaces

DS 211 (AUG) 3:0

Numerical Optimization

Numerical properties of modified Newton, quasi-Newton, steepest descent, nonlinear conjugate gradient, trust-region methods for unconstrained optimization, line search methods for all problems, simplex, barrier, penalty, sequential quadratic programming, reduced gradient, augmented lagrangian, sequential linearly constrained, Convergence and numerical analysis of algorithms for unconstrained problems, Various methods for solving matrix problems that are relevant to the efficient solution of KKT systems and to solving the sequence of linear problems that arise in optimization algorithms, matrix factorization updating and the linear conjugate gradient algorithm, numerical optimality conditions for smooth optimization problems

Atanu Kumar Mohanty, Phaneendra Kumar Yalavarthy

Basic knowledge of Numerical Methods,Basic knowledge of Linear Algebra,Consent from Advisor

DS 290 (AUG) 3:0

Modelling and Simulation

Soumyendu Raha

P.E Kloeden, Platen, E., Numerical Solution of Stochastic Differential Equations . Springer, Berlin. doi : 10.1007/978 - 3 - 662 - 12616 - 5 . ISBN 978 - 3 - 540 - 54062 - 5 , ,1992,Banks, J., Carson, J. S., Nelson, B. L., & Nicol, D. M. (2013). Discrete-event system simulation: Pearson new international edition. Pearson Higher Ed.,Asmussen, S., & Glynn, P. W. (2007). Stochastic simulation: algorithms and analysis (Vol. 57). Springer Science & Business Media.

DS 290 (AUG) 3:0

Modelling and Simulation

Statistical description of data, data-fitting methods, regression analysis, analysis of variance, goodness of fit. Probability and random processes, discrete and continuous distributions, Central Limit theorem, measure of randomness, Monte Carlo methods. Stochastic Processes and Markov Chains, Time Series Models. Modelling and simulation concepts,Discrete-event simulation: Event scheduling/Time advance algorithms verification and validation of simulation models. Continuous Simulation: Modelling with and Simulation of Stochastic Differential Equations.

Soumyendu Raha

Consent from Advisor,Basic course on numerical methods,Good knowledge of basic mathematics

DS 222 (AUG) 3:1

Machine Learning with Large Datasets

Streaming algorithms and Naive Bayes, fast nearest neighbor, parallel perceptrons, parallel SVM, randomized algorithms, hashing, sketching, scalable SGD, parameter servers, graph-based semi-supervised learning, scalable link analysis, large-scale matrix factorization, speeding up topic modeling, big learning and data platforms, learning with GPUs.

Partha Pratim Talukdar

Consent from Advisor,Prior exposure to machine learning,Basics of algorithms

DS 221 (AUG) 3:1

Introduction to Scalable Systems

1) Architecture: computer organization, single-core optimizations including exploiting cache hierarchy and vectorization, parallel architectures including multi-core, shared memory, distributed memory and GPU architectures; 2) Algorithms and Data Structures: algorithmic analysis, overview of trees and graphs, algorithmic strategies, concurrent data structures; 3) Parallelization Principles: motivation, challenges, metrics, parallelization steps, data distribution, PRAM model; Parallel Programming Models and Languages: OpenMP, MPI, CUDA; 4) Big Data Platforms: Spark/MapReduce model, cloud computing.Lab tutorials and programming assignments for above topics.

Sathish S Vadhiyar, Yogesh L Simmhan

Basics of computer systems,Basic data structures and programming,Basic algorithms,Consent of instructor

DS 288 (AUG) 3:0

Numerical Methods

Root finding: Functions and polynomials, zeros of a function, roots of a nonlinear equation, bracketing, bisection, secant, and Newton-Raphson methods. Interpolation, splines, polynomial fits, Chebyshev approximation. Numerical Integration and Differentiation: Evaluation of integrals, elementary analytical methods, trapezoidal and Simpson’s rules, Romberg integration, Gaussian quadrature and orthogonal polynomials, multidimensional integrals, summation of series, Euler-Maclaurin summation formula, numerical differentiation and estimation of errors. Optimization: Extremization of functions, simple search, Nelder-Mead simplex method, Powell’s method, gradient-based methods, simulated annealing. Complex analysis: Complex numbers, functions of a complex variable, analytic functions, conformal mapping, Cauchy’s theorem. Calculus of residues. Fourier and Laplace Transforms, Discrete Fourier Transform, z transform, Fast Fourier Transform (FFT), multidimensional FFT, basics of numerical optimization.

Sashikumaar Ganesan

Consent from Advisor,Good knowledge of basic mathematics,Basic programming skill,Basic knowledge of multivariate calculus and elementary real analysis

DS 301 (AUG) 2:0

Bioinformatics

Biological Databases: Organisation, searching and retrieval of information, accessing global bioinformatics resources using internet links. Introduction to Unix operating system and network communication. Nucleic acids sequence assembly, restriction mapping, finding simple sites and transcriptional signals, coding region identification, RNA secondary structure prediction. Similarity and Homology, dotmatrix methods, dynamic programming methods, scoring systems, multiple sequence alignments, evolutionary relationships, genome analysis. Protein physical properties, structural properties – secondary structure prediction, hydrophobicity patterns, detection of motifs, structural database (PDB). Genome databases, Cambridge structure database, data mining tools and techniques, Structural Bioinformatics, Topics from the current literature will be discussed.

Sekar K, Debnath Pal

Consent from Advisors,Basic knowledge of mathematics,Basic knowledge of molecules

DS 295 (JAN) 3:1

Parallel Programming

Parallel Algorithms: MPI collective communication algorithms including prefix computations, sorting, graph algorithms, GPU algorithms; Parallel Matrix computations: dense and sparse linear algebra, GPU matrix computations; Algorithm models: Divide-and-conquer, Mesh-based communications, BSP model; Advanced Parallel Programming Models and Languages: advanced MPI including MPI-2 and MPI-3, advanced concepts in CUDA programming; Scientific Applications: sample applications include molecular dynamics, evolutionary studies, N-Body simulations, adaptive mesh reinements, bioinformatics; System Software: sample topics include scheduling, mapping, performance modeling, fault tolerance.

Sathish S Vadhiyar

Consent from Advisor,DS 221 Introduction to scalable systems,A graduate level course on algorithms,Fundamentals of MPI,OpenMP and GPU architectures

DS 265 (JAN) 3:1

Deep Learning for Computer Vision

Computer vision – brief overview; Machine Learning – overview of selected topics ; Introduction to Neural Networks, Backpropagation, Multi-layer Perceptrons ; Convolutional Neural Networks ; Training Neural Networks ; Deep Learning Software Frameworks ; Popular CNN Architectures ; Recurrent Neural Networks ; Applications of CNNs- Classification, Detection, Segmentation, Visualization, Model compression ; Unsupervised learning ; Generative Adversarial Networks.

Venkatesh Babu R

Consent from Advisor,Basic knowledge of Computer Vision and Machine Learning,Proficiency in Python,C/C++

DS 291 (JAN) 3:1

Finite Elements: Theory and Algorithms

Generalized (weak) derivatives, Sobolev norms and associated spaces, inner-product spaces, Hilbert spaces, construction of finite element spaces, mapped finite elements, two- and three-dimensional finite elements,Interpolation and discretization error, variational formulation of second order elliptic boundary value problems, finite element algorithms and implementation for linear elasticity, Mindlin-Reissner plate problem, systems in fluid mechanics

Sashikumaar Ganesan

Consent from Advisor,Good knowledge of numerical analysis,Basic programming skill

DS 200 (JAN) 0:1

Research Methods

This course will develop the soft skills required for the CDS students. The modules (each spanning 3 hours) that each student needs to complete include: Seminar attendance, literature review, technical writing (reading, writing, reviewing), technical presentation, CV/resume preparation, grant writing, Intellectual property generation (patenting), incubation/start-up opportunities, and academia/industry job search.

Debnath Pal, Phaneendra Kumar Yalavarthy

Consent from Advisor,Basic knowledge of english,Basic comprehension skills

DS 391 (JAN) 3:0

Data Assimilation to Dynamical Systems

Quick introduction to nonlinear dynamics: bifurcations, unstable manifolds and attractors, Lyapunov exponents, sensitivity to initial conditions and concept of predictability. Markov chains, evolution of probabilities (Fokker-Planck equation), state estimation problems. An introduction to the problem of data assimilation (with examples) Bayesian viewpoint, discrete and continuous time cases Kalman filter (linear estimation theory) Least squares formulation (possibly PDE examples) Nonlinear Filtering: Particle filtering and MCMC sampling methods. Introduction to Advanced topics (as and when time permits): Parameter estimation, Relations to control theory, Relations to synchronization.

Soumyendu Raha

Consent from Advisor,Good knowledge of basic mathematics,Basics of data science

DS 299 (JAN) 0:28

Dissertation Project

This includes the analysis, design of hardware/software construction of an apparatus/instruments and testing and evaluation of its performance. The project work is usually based on a scientific/engineering problem of current interest. Every student has to complete the work in the specified period and should submit the Project Report for final evaluation. The students will be evaluated at the end first year summer for 4 credits. The split of credits term wise is as follows 0:4 Summer, 0:8 AUG, 0:16 JAN.

Consent from Advisor,Literature review,Clear idea about the research project

DS 294 (JAN) 3:0

Data Analysis and Visualization

Data pre-processing, data representation, data reconstruction, machine learning for data processing, convolutional neural networks, visualization pipeline, isosurfaces, volume rendering, vector field visualization, applications to biological and medical data, OpenGL, visualization toolkit, linear models, principal components, clustering, multidimensional scaling, information visualization.

Phaneendra Kumar Yalavarthy, Anirban Chakraborty

Consent from Advisors,Basic knowledge of numerical methods,Good knowledge of basic mathematics

DS 252 (JAN) 3:1

Cloud Computing

(*) Context: Taxonomy of parallel and distributed computing; shared/distributed memory, and data/task parallel computing; Role of Cloud computing. (*) Technology: Cloud Virtualization, Elastic computing; Infrastructure/Platform/Software as a Service (IaaS/PaaS/SaaS); Public/Private Clouds; Service oriented architectures. (*) Design Patterns: Design of task/data parallel distributed algorithms; Cloud applications; Task graphs and Map-Reduce model; Amdahl's law, data locality, speedup of Cloud applications. (*) Execution Models: Synchronous/asynchronous execution patterns; Scale up/Scale out on VMs; Data marshalling/unmarshalling; Asynchronous coordination of concurrent tasks on VMs; NoSQL Cloud storage. (*) Evaluation: Load balancing of stateful/stateless applications; Performance metrics for evaluating Cloud applications; Consistency, Availability and Partitioning (CAP theorem). (*) Programming project using public Cloud infrastructure e.g. Amazon AWS, Microsoft Azure Cloud resources provided.

References:
* Distributed and Cloud Computing: From Parallel Processing to the Internet of Things, Kai Hwang, Jack Dongarra and Geoffrey Fox, Morgan Kaufmann, 2011
* Current literature

Yogesh L Simmhan

Data Structures,Algorithms,Programming experience,DS 221,Instructor approval

DS 397 (JAN) 2:1

Topics in Embedded Computing

Introduction to embedded processing, dataflow architectures, architecture of embedded SoC platforms, dataflow process networks, compiling techniques/optimizations for stream processing, architecture of runtime reconfigurable SoC platforms, simulation, design space exploration and synthesis of applications on runtime reconfigurable SoC platforms, additional topics including but not limited to computation models for coarse grain reconfigurable architectures (CGRA), readings and case study of REDEFINE architecture, compiler back-ends for CGRAs.

Nandy S K

Consent from Advisor,Basic knowledge of digital electronics,computer organization and design,Basic knowledge of computer architecture,data structures and algorithms

DS 211 (JAN) 3:0

Numerical Optimization

Numerical properties of modified Newton, quasi-Newton, steepest descent, nonlinear conjugate gradient, trust-region methods for unconstrained optimization, line search methods for all problems, simplex, barrier, penalty, sequential quadratic programming, reduced gradient, augmented lagrangian, sequential linearly constrained, Convergence and numerical analysis of algorithms for unconstrained problems, Various methods for solving matrix problems that are relevant to the efficient solution of KKT systems and to solving the sequence of linear problems that arise in optimization algorithms, matrix factorization updating and the linear conjugate gradient algorithm, numerical optimality conditions for smooth optimization problems.

Atanu Kumar Mohanty

Consent from Advisors,Basics of linear algebra,Basics of Numerical Methods

DS 256 (JAN) 3:1

Scalable Systems for Data Science

This course will teach the fundamental Systems aspects of designing and using Big Data platforms, which are a specialization of scalable systems for data science applications.1) Design of distributed program models and abstractions, such as MapReduce, Dataflow and Vertex-centric models, for processing volume, velocity and linked datasets, and for storing and querying over NoSQL datasets.2) Approaches and design patterns to translate existing data-intensive algorithms and analytics into these distributed programming abstractions.3) Distributed software architectures, runtime and storage strategies used by Big Data platforms such as Apache Hadoop, Spark, Storm, Giraph and Hive to execute applications developed using these models on commodity clusters and Clouds in a scalable manner. Students will work with real, large datasets and commodity clusters, and use scalable algorithms and platforms to develop a Big Data application.

See http://cds.iisc.ac.in/courses/ds256/ for details

Yogesh L Simmhan

Data Structures and Algorithms,Strong programming experience preferably in Java,Courses like DS 221; DS 252; DS 222; or E0 251

DS 289 (JAN) 3:1

Numerical Solution of Differential Equations

Ordinary differential equations: Lipschitz condition, solutions in closed form, power series method. Numerical methods: error analysis, stability and convergence, Euler and Runge-Kutta methods, multistep methods, Adams-Bashforth and Adams-Moulton methods, Gear’s open and closed methods, predictor-corrector methods. Sturm-Liouville problem: eigenvalue problems, special functions, Legendre, Bessel and Hermite functions. Partial differential equations: classification, elliptic, parabolic and hyperbolic PDEs, Dirichlet, Neumann and mixed boundary value problems, separation of variables, Green’s functions for inhomogeneous problems. Numerical solution of PDEs: relaxation methods for elliptic PDEs, Crank-Nicholson method for parabolic PDEs, Lax-Wendroff method for hyperbolic PDEs. Calculus of variations and variational techniques for PDEs, integral equations. Finite element method and finite difference time domain method, method of weighted residuals, weak and Galerkin forms, ordinary and weighted/general least squares. Fitting models to data, parameter estimation using PDEs.

Atanu Kumar Mohanty

Consent from Advisors,Basic course on numerical methods,Good knowledge of basic mathematics

DS 255 (JAN) 3:1

System Virtualization

Virtualization as a construct for resource sharing; Re-emergence of virtualization and it’s importance for Cloud computing; System abstraction layers and modes of virtualization; Mechanisms for system virtualization – binary translation, emulation, para-virtualization and hardware virtualization; Virtualization using HAL layer – Exposing physical hardware through HAL (example of x86 architecture) from an OS perspective; System bootup process; Virtual Machine Monitor; Processor virtualization; Memory Virtualization; NIC virtualization; Disk virtualization; Graphics card virtualization; OS-level virtualization and the container model; OS resource abstractions and virtualization constructs (Linux Dockers example) ; Virtualization using APIs – JVM example.

Lakshmi Jagarlamudi

Consent from Advisor,Basic course on operating systems,Basic programming skill

DS 260 (JAN) 3:0

Medical Imaging

X-ray Physics, interaction of radiation with matter, X-ray production, X-ray tubes, dose, exposure, screen-film radiography, digital radiography, X-ray mammography, X-ray Computed Tomography (CT). Basic principles of CT, single and multi-slice CT. Tomographic image reconstruction, filtering, image quality, contrast resolution, CT artifacts. Magnetic Resonance Imaging (MRI): brief history, MRI major components. Nuclear Magnetic Resonance: basics, localization of MR signal, gradient selection, encoding of MR signal, T1 and T2 relaxation, k-space filling, MR artifacts. Ultrasound basics, interaction of ultrasound with matter, generation and detection of ultrasound, resolution. Doppler ultrasound, nuclear medicine (PET/SPECT), multi-modal imaging, PET/CT, SPECT/CT, oncological imaging, medical image processing and analysis, image fusion, contouring, segmentation, and registration.

Phaneendra Kumar Yalavarthy

Consent from Advisor,Basic knowledge of system theory,Good knowledge of basic mathematics

DS 323 (MAY) 1:1

Parallel Computing for Finite Element Methods

This course will provide an introduction to parallel finite element data structure and its efficient implementation in ParMooN (Parallel Mathematics and object oriented Numerics), an open source parallel finite element package. Further, the implementation of the parallel (MPI/OpenMPI) geometric multigrid solver will also be taught. Parallel finite element solution of scalar and incompressible Navier-Stokes equations in two- and three-dimensions using ParMooN (cmg.cds.iisc.ac.in/parmoon/) will also be a part of this course.

Sashikumaar Ganesan

Consent from Advisor,Good knowledge of finite element methods,C/C++,Sashikumaar Ganesan, Lutz Tobiska: Finite elements: Theory and Algorithms, Cambridge-IISc Series, Cambridge University Press, 2017.,An Introduction to Parallel Programming. Peter S Pacheco. Publisher: Morgan Kauffman. ISBN: 978-93-80931-75-3. 2011.

Dept of Management Studies

Master of Management (M.Mgt) Program
Duration: 2 years

Hard Core: 24 credits
MG 201 3:0 Managerial Economics
MG 211 3:0 Human Resource Management
MG 212 2:1 Behavioral Science
MG 221 2:1 Applied Statistics
MG 232 3:0 Principles of Management
MG 241 3:0 Marketing Management
MG 251 3:0 Finance & Accounts
MG 261 3:0 Operations Management
Stream Core: 12 Credits (to be chosen from either one of the two streams)

Stream 1: Business Analytics Stream
MG 223 3:0 Applied Operations Research
MG 225 3:0 Decision Models
MG 226 3:0 Time Series Analysis and Forecasting
MG 265 2:1 Data Mining

Stream 2: Technology Management Stream
MG 271 3:0 Technology Management
MG 274 3:0 Management of Innovation and ntellectual Property

MG 281 3:0 Management of Technology for Sustainability
MG 298 2:1 Entrepreneurship for Technology Start-ups

Electives: 12 credits

Project: : **MG 299 0:16 Management Project**

Summer Internship: No credits. Every student is required to spend a minimum of eight weeks in an identified industrial enterprise or public sector organization during the summer period after the first two semesters. Alternatively students have the option to get exposure to business incubators, venture capital firms and successful start-ups.

MG 201 (AUG) 3:0

Managerial Economics

Introduction to managerial economics, demand theory and analysis, production theory, cost theory, market structure and product pricing, Pricing of goods and services, pricing and employment of inputs. Micro and macro economics, national income accounting, GDP measurement, inflation and price level, aggregate demand and supply, fiscal and monetary policy.

Balasubrahmanya M H

Allen,Bruce et al: Managerial Economics: Theory,Applications,and Cases,WW Norton

MG 202 (AUG) 3:0

Macroeconomics

Macroeconomics: Overview, national income accounting, measurement of GDP in India, inflation and its measurement, price indices in India, aggregate demand and aggregate supply.

India'smacroeconomic crisis: causes and dimensions. Keynesian Theory, money and banking.

How banks create money.

Monetary Policy: Its instruments and uses, monetary policy in India, monetarism, supply side fiscal policies, Philipp's curve and theory of rational expectations. Case studies on macroeconomic issues.

Balasubrahmanya M H

Ministry of Finance: Economic Survey,Government of India,Recent Issues.,Froyen,Macroeconomics: Theories and Policies

MG 212 (AUG) 2:1

Behavioral Science

Understanding human behaviour; functionalist, cognitive, behaviouristic and social learning theories; perception; learning; personality; emotions; defense mechanisms; attitude; communication; decision making; groups and social behaviour; intra-personal and inter-personal differences; managing conflicts.

Anjula Gurtoo

Luthans,F,Organizational Behaviour,McGraw-Hill,1988. Weiten

MG 242 (AUG) 3:0

Strategic Management

Strategic management process, challenge of globalization, strategic planning in India. Corporate governance, board of directors. Role and functions of top management. Environmental scanning; industry analysis; internal scanning; organizational analysis. Strategy formulation: situation analysis and business strategy, corporate strategy, functional strategy, strategy implementation and control, strategic alternatives. Diversification, mergers and acquisition

Parthasarathy Ramachandran

R. Srinivasan, Strategic Management – The Indian Context, Prentice-Hall of India, 5th Edition, 2014.,R. Srinivasan, Case Studies in Marketing – The Indian Context, Prentice-Hall of India, 6th Edition, 2014.,None

MG 265 (AUG) 3:0

Data Mining

Introduction to data mining. Data mining process. Association rule mining: Apriori and FP tree. Classification: ID3, C4.5, Bayes classifier. Clustering: K-means, Gaussian mixture model. Bayesian belief networks. Principal component analysis. Outlier detection.

Parthasarathy Ramachandran

Jiawei Han and Micheline Kamber, Data Mining: Concepts and Techniques, Morgan Kaufman Publishers 2001.,Richard J. Roiger and Michael W Geatz, Data Mining: A Tutorial-Based Primer, Addison-Wesley 2003,Mehmed Kantardzic, Data Mining: Concepts, Models, Methods and Algorithms, Wiley, 2003

MG 251 (AUG) 3:0

Finance and Accounts

Nature and purpose of accounting, financial statements: learning, understanding the basic financial statements. Preparation of P and L account, balance sheet, basic accounts and trial balance. Income measurement, revenue recognition, depreciation accounting. Cash flow statements. Analysis and interpretation of financial statements; concepts and elements of cost, activity based costing. CVP analysis, break-even point, marginal costing, relevant costing.

Cost analysis for decision making: opportunity cost concept, dropping a product, pricing a product, make-or-buy and product mix decisions. Joint products, by-products. Process costing. Standard costing, budgeting – flexible budget, master budget, zero based budgeting. Overview of Financial Management, time value of money, fund and cash flow statement, risk and return. Working capital management: estimating working capital, financing working capital, receivables management, inventory management, cash management, money markets in India.

Capital Budgeting: appraising long term investment projects, make vs. buy investment decisions, estimating relevant cash flow. Capital Structure: Estimation of cost of debt, cost of equity, overall cost of capital, CAPM. Capital structure planning: Capital structure policy and target debt equity structure, EBIT-EPS analysis. Leasing. Introduction to valuation of firm. Introduction to derivatives.

Parthasarathy Ramachandran

Anthony and Reece, Accounting Principles, AITBS, Sixth Edition, 1998,S.K. Bhattacharyya and John Dearden, Accounting for Management, Vikas Publishing House, Third Revised Edition, 1998.,Horngren, Foster and Dattar, Cost Accounting, PHI Publication, Tenth Edition.,Brearly R. and Myers S, Principles of Corporate Finance, McGraw-Hill, New Delhi, Fifth Edition.,Prasanna Chandra, Financial Management: Theory and Practice, Tata McGraw-Hill, Fifth Edition.

MG 271 (AUG) 3:0

Technology Management

Definition of technology, technological transformation process, adaption. Adaption and innovation experiences in selected developed and developing countries. Technology transfer and its relation to technology transformation, diffusion and commercialization, rural technology management. Forward and backward integration. Some concepts in relation to technology management – productivity, employment, human resource and organizational development and corporate strategy.

MOT scope and focus, measuring technology content and intensity, organizing the high technology enterprise. Concurrent engineering and integrated product development, managing technology based projects, technology evaluation and selection, leading technology teams.

Akhilesh K B

Thahaman,H.J.,Management of Technology,New Jersey: John Wiley & Sons,2005.

MG 225 (AUG) 3:0

Decision Models

Analytical hierarchy process: structuring of a problem into a hierarchy consisting of a goal and subordinate features of the problem, and pairwise comparisons between elements at each level. Goal programming: Pareto optimality, soft constraints, identifying the efficient frontier, duality and sensitivity analysis. Data envelopment analysis: relative efficiency measurements, DEA model and analysis, graphical representation, and dual DEA model. Agent based modeling: complex adaptive systems, emergent structures and dynamic behaviors. Discrete event simulation: random number generators and generating random variates. Selecting input probability distributions and output data analysis. Neural networks: neuron model and network architecture, perceptron learning rule, and back propagation. Support vector machines: Learning methodology, linear learning machines, kernel-induced feature spaces.

Parthasarathy Ramachandran

Saaty, T. L., The Analytic Hierarchy Process, McGraw-Hill, 1990.,Rardin, R. L., Optimization in Operations Research, Pearson, 2005.,Law, A. M. and Kelton, D. W., Simulation Modeling and Analysis, McGraw-Hill, 1991.,Mitchell, T., Machine learning, McGraw-Hill, 1997.

MG 232 (AUG) 3:0

Principles of Management

Scientific techniques of management, Evolution of management thought, contributions of Taylor, Gilbreth, Henri Fayol and others. Levels of authority and responsibilities. Types of managerial organizations, line, staff, committee, etc. Social responsibilities of management, internal and external structure of organizations, charts and manuals, formulation and interpretation of policy, Issue of instructions and delegation of responsibility, functional team-work, standards for planning and control.

Harold Koontz and Heinz Weihrich,Essentials of Management – An International Perspective,Tata McGraw Hill Education Pvt. Ltd.,New Delhi,8th Edition

MG 221 (AUG) 2:1

Applied Probability and Statistics

Probability spaces, laws and calculations; distributions and moments of discrete and continuous univariate and multivariate random variables and vectors; binomial, Poisson, negative binomial, uniform, normal and gamma models. Poisson processes. Criteria and methods of estimation – UMVU, MM, ML. Testing statistical hypotheses – fixed and observed significance level testing. One and two sample problems for mean, variance and proportions – Z-test, t-test, chi-square-test, F-test, sign test, Wilcoxon rank–sum and signed-rank test. Chi-square-test of homogenity, independence and goodness-of-fit.

Mukhopadhyay C

Douglas C. Montgomery & George C. Runger,Applied Statistics and Probability for Engineers,Wiley India Pvt. Ltd.,Fifth Edition,2014

MG 261 (AUG) 3:0

Operations Management

Introduction to Production/Operations Management (P/OM), P/OM strategy, forecasting, process management, facility layout, capacity planning and facility planning, aggregate planning, material requirement planning, scheduling, inventory management, waiting line, project management, management of quality. Introduction to simulation and to supply chain management.

Mathirajan M

Stevenson,William,J.,Production/Operations Management. 6th Edition. Irwin/McGraw-Hill.,Krishnaswamy

MG 241 (JAN) 3:0

Marketing Management

Marketing function, marketing concept, relationship with other functions, relevance, marketing environment, markets. Consumer behavior, market segmentation, marketing planning, marketing mix, Product policy, new products, product life cycle. Pricing, distribution. Advertising and promotion. Marketing organization. Sales forecasting. Management of sales force, marketing control.

Parthasarathy Ramachandran

Phillip Kotler,Marketing Management - Analysis,Planning and Control,13th Edition,Prentice-Hall of India

MG 211 (JAN) 3:0

Human Resource Management

Historical development - welfare to HRM in India. Personnel functions of management. Integrated HRPD system, human resource planning, job analysis, recruitment and selection, induction, performance appraisal and counseling, career planning and development, assessment center, wage and salary administration, incentives, benefits and services. Labour legislation - Industrial Disputes Act, Indian Trade Unions Act, Industrial Employment (Standing Orders) Act, dealing with unions, workers participation and consultation, grievance handling, employee relations in a changing environment, occupational health and safety, employee training and management development, need analysis and evaluation, managing organizational change and development. Personnel research, human resource management in the future.

Akhilesh K B

DeCenzo and Robbins,Personnel and Human Resource Management,Prentice Hall,1988.,Werther and Davis

FL 141 (JAN) 3:0

Preliminary Course in Russian

Phonetics, speech patterns, tables, lexical and grammatical exercises and dialogues

I.S. Krishtofova and T.S. Gamzkova,Russian Language For All.,L. Muravyova,Verbs of Motion in Russian,Russian Language Publishers

MG 277 (JAN) 3:0

Public Policy Theory and Process

Introduction to policy; conceptual foundations; practice of policy making; theories: social, institutional rational choice, punctuated equilibrium, and stages; frameworks and models; government and politics; rationality and governance; role of rules, strategies, culture and resources; member dynamics (institutional and non-institutional); analysis: meta, meso decision and delivery levels.

Anjula Gurtoo

Weimer,D.L.,and Vining A.R.,Policy Analysis: concepts and practice,Prentice Hall

MG 222 (JAN) 3:0

Regression and Time Series Analysis

Simple and multiple linear regression modeling, general linear hypotheses testing, and prediction; multiple and partial effects and correlations; residual analysis; dummy variable techniques (analysis of covariance). Classical decomposition of time series into trend, cyclical, seasonal and irregular components. Elementary trend modeling - growth models, polynomial and logistic trends. Stationary stochastic processes - auto-covariance and partial auto-correlation functions; MA, AR and ARMA models – Impulse Response Function, Auto Correlation Analysis and forecasting. Stochastic trends – unit root tests, ARIMA modeling, forecasting. Seasonality modeling – SARIMA models.

Mukhopadhyay C

Michael H. Kutner,Christopher J. Nachtsheim,John Neter & William Li,Applied Linear Statistical Models,McGraw-Hill International Edition

MG 246 (JAN) 3:0

Customer Segmentation and Insights

Develop a deep actionable understanding of customers using a disciplined approach to give companies a competitive advantage using customer research, analytics and experimentation. Numeric data, language data and image data analysis, verbal and non-verbal communication skills, and presentation techniques. What is Customer Segmentation? How is it useful for organizations? What are Customer Insights? What are “product-out” verses “market-in” approaches? What is a “purchase journey?” What is Customer Experience Management? Illustrated with examples. How to get a holistic picture (360o view) of the customer base? Collecting quantitative and qualitative (emotions) data about customers. How is customer segmentation done using data analytics? Illustrative examples. What are the different stages in the purchase journey? How do we know which of these “touchpoints” are of value (moments of truth) to target customer segments? How does one benchmark with competition? Some practical approaches to connect with customers to get insights. Determining the “latent needs” of the customer by using image and language data (Voice of Customer), art of active listening and observing customer behavior. Developing the Kano Questionnaire, Conducting the Kano survey. Analyzing the Kano results including cross-tabulation of customer attributes, developing product/ service concepts (experiments), conducting a pilot, evaluating the effectiveness of the experiments. What are the tools available to deliver a differentiated customer experience at those “moments of truths?” How does “digital” play a role in enhancing customer experience?

Parthasarathy Ramachandran

McDonald, Emma K, Wilson, Hugh N, and Konus, Umut: Better Customer Insight, HBR September 2012.,Shen, Diane: Developing and Administering Kano Questionnaires on Kano's Methods for Understanding Customer-defined Quality, Center for Quality of Management Journal, Fall 1993.,Shiba, Shoji and Walden, David (2006): Breakthrough Management, CII.,Shiba, Shoji and Walden, David (2012): Four Practical Revolutions in Management, Productivity Press.

MG 286 (JAN) 3:0

Project Management

The systems approach, project organization, work definition, scheduling and network analysis, PERT and CPM, resource–constrained scheduling, project costing and assessment, project control and management, software for project management, management of hi-tech projects, including software projects, quality and risk management.

Parameshwar P Iyer, Parthasarathy Ramachandran

Iyer, Parameshwar P., Engineering Project Management with Case Studies, Vikas Publishing, New Delhi, 2009.,Project Management Institute, USA. A Guide to the Project Management Body of Knowledge. Newton Square, PA. 1996.,Meredith, J.R., and Mantel, S.J. Jr., Project Management: A Managerial Approach, John Wiley and Sons, NY, 1995.

MG 223 (JAN) 3:0

Applied Operations Research

Introduction to management decision making and operations research. Fundamentals of linear programming. Alternative ways of formulating practical linear programming models. Their advantages and disadvantages. Case studies and applications of linear programming. Solution approaches, implications of sensitivity analysis. Transportation and assignment programming. Sensitivity analysis in transportation programming; integer programming formulations and applications. Basics of heuristic optimization. Dynamic programming. Applications of dynamic programming [Entire course will use real-life business applications].

Parthasarathy Ramachandran

Anderson,Sweeny,and Williams,An Introduction to Management Science: Quantitative Approaches to Decision Making,11th Edition

MG 274 (JAN) 3:0

Management of Innovation and Intellectual Property

Organizational and technological innovation – definition of innovation vs inventions, role of organizational design and processes – strategic role of intellectual property protection in case studies, the R&D value chain, stage gates, differences in priority with the R&D value chain, NPD - international, national, organizational, individual actors, organizations and vehicles to manage intellectual property, critical steps in managing R&D, process management during stage gates for patent searches, technology landscaping, specification writing, timeline management, rights and responsibilities in competitive technology environments, innovative inventions, commercial potential, processes to enhance technological know-how transfer, open source approach, incubators, assessing patent value, information technology support systems in managing innovation and intellectual property, prior art laboratories sessions and working with a client.

Parthasarathy Ramachandran

Trott, P., Innovation Management and New Product Development, Financial Times, Pitman Publishing, GB, 1998.,Petrusson, U., Intellectual Property and Entrepreneurship, Creating Wealth in an Intellectual Value Chain, CIP Working Paper Series, Centre for Intellectual Property Studies, Gotenburg, Sweden, 2004.,Rivette, K.G. & Kline, D., Rembrandts in the Attic, Unlocking the Hidden Value of Patents, Harvard Business School Press, Boston, Massachusetts, 2000.

MG 281 (JAN) 3:0

Management of Technology for Sustainability

Concepts of sustainability and sustainable development. Components of sustainability (social, economic, environmental). Linkages between technology and sustainability. Sustainability proofing of technology life cycle. Frameworks for measuring sustainability. Indicators of sustainability. Interactions between energy and technology and their implications for environment and sustainable development. Technological innovations for sustainability. Sustainable innovations – drivers and barriers. Policy and institutional innovations for sustainability transition.

Balachandra P

Dorf,Richard C.,Technology,humans,and society: toward a sustainable world

MG 299 (JAN) 0:16

Management Project

The project work is expected to give intensive experience for a student with respect to industrial organizations or institutions in the context of chosen field of specialization. Students are encouraged to carryout individual project works.

Parthasarathy Ramachandran

None,None,None

MG 226 (JAN) 3:0

Advanced Analytics

Mukhopadhyay C

MG 258 (JAN) 3:0

Financial instruments and risk management strategies

Shashi Jain

MG 227 (JAN) 3:0

Advanced Analytics

Mukhopadhyay C

INTERDISCIPLINARY PROGRAM - CYBER PHYSICAL SYSTEM

CP 311 (AUG) 2:1

Dynamics and Control of Smart Materials

This course will be taught jointly with Josephine Selvarani Ruth D.Introduction to smart/intelligent materials, artificial intelligence vs embedded inherent intelligence smart systems, definitions and implications, components of smart systems, role of smart materials in developing active intelligent systems. Dynamics of high bandwidth low strain smart systems (piezoelectrics, magnetostrictive), types of piezoelectric materials, generator and motor principle, constitutive relationship, unimorph and bimorph actuators, design of sensing and actuating smart systems, application examples.Dynamics of high strain low bandwidth systems (shape memory alloys, electro-active polymers, magnetostrictive, electrostrictive), phase transformations, characteristics of SMA control, modelling approach, Design of actuators –damper, compliant, variable impedance actuator, self-sensing actuator, application examples.Design and control of hybrid smart systems (System identification, controller, MATLAB Simulink), intelligent system design, factors to be considered in selection of smart materials to develop a smart systems, optimal placement, dynamics of smart hybrid system, modelling features, concepts of sensor –actuator integration, amalgamation of smart materials and control system.Shared sensing and actuation, self-sensing actuation, techniques of dual functionality, developing a smart device in a networking dual control loop systems. Laboratory experiments will be given on the above topics Prerequisites: Undergraduate engineering courses

Bharadwaj Amrutur

[1] Culshaw B., Smart structures and Materials, Artech house, 1996,Leo, D. J., Engineering Analysis of Smart Material Systems, Wiley, 2007.,Gauenzi, P., Smart Structures Physical Behaviour, Mathematical Modelling and Applications, Wiley, 2009.,Srinivasan, A. V., Michael McFarland D., Smart structure analysis and design, Cambridge University Press, 2001.

CP 312 (AUG) 3:0

Robot Dynamics and Control

This course will be taught jointly with Shishir N. Y. Kolathaya.Configuration spaces, task spaces, rotation groups, rigid transformations, forward and inverse kinematics, forward and inverse dynamics, holonomic and nonholonomic constraints, Lyapunov stability, feedback linearization of robotic systems, safety in robotic systems, control Lyapunov functions, control barrier functions, hybrid systems, hybrid modeling and stability of bipedal robots.

Prerequisites:Students must be well versed with basic mathematical concepts like linear algebra and classical analysis. Suggested courses are MA 219 and MA 221.

Shalabh Bhatnagar

Murray, Li, Sastry, A Mathematical Introduction to Robot Manipulation, CRC Press, 1994,Song, Hutchinson and Vidyasagar, Robot Modeling and Control, Wiley 2005,H. Khalil, Nonlinear Systems, 3rd edition, Prentice Hall, 2002,A. Ghosal, Robotics: Fundamental Concepts and Analysis, Oxford, 2006,S. Sastry, Nonlinear Systems: Analysis, Stability, and Control, Springer 1999

CP 313 (AUG) 2:1

Autonomous Navigation

This course will be co-taught with Raghu Krishnapuram.Autonomous robots (including self-driving cars and drones) are good examples of highly complex cyber-physical systems (CPSs) with an array of sensors and actuators that may possess external connectivity to other infrastructure. Autonomous robots are set to be game changers in several areas such as infrastructure maintenance, transportation, public safety, rescue operations, disaster response, agriculture, mining, surveillance, public safety, health care, unmanned cargo, and exploration. Autonomous navigation lies at heart of autonomous robots, and involves a highly multidisciplinary approach. It includes a variety of subject areas such as perception and sensor technologies (such as IMU, GPS, LiDAR, and wheel odometry), behaviour modelling, trajectory prediction, localization and mapping methods (including visual odometry), and motion/path planning in the presence of obstacles. This 14-week course will cover the main theoretical concepts and practical approaches to autonomous navigation through a combination of lectures, associated hands-on lab assignments as well as individual and group projects.Prerequisites: Random Processes (E2 202) or Probability and Statistics (E0 232) or its equivalent, Linear Algebra and Applications (E0 219) or its equivalent, and Data structures and algorithms (E0 251) or its equivalent. In addition, Knowledge of basic optimization methods, algorithm design (including dynamic programming), basics of machine learning and computer vision will be assumed.

Chiranjib Bhattacharyya

PROBABILISTIC ROBOTICS, Sebastian Thrun, Wolfram Burgard, D. Fox, MIT Press, 2005.,BAYESIAN ESTIMATION OF TIME-VARYING SYSTEMS: DISCRETE TIME SYSTEMS, Simo Sarkka, Aalto University, 2010.,COMPUTER VISION: ALGORITHMS AND APPLICATIONS, Richard Szeliski, Springer, 2010.

CP 211 (JAN) 3:0

Introduction to Switched and Hybrid System

Shalabh Bhatnagar