Scheme of Instruction 2019-20

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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 with the consent of the instructors.

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 instructors. 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. Student are assigned faculty advisors who willadvise themin selectingand droppingcourses, and monitor progress through the academic program. In order to register for a course, each student 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.

31stJuly 2019

Prabhu R Nott

Chair, Senate Curriculum Committee

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 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)

Biological Science

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, Anand Srivastava

Pre-requisites:

- 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

References:

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

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, Purusharth Rajyaguru

References:

- 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 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

Pre-requisites:

- 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

Pre-requisites:

- 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

Pre-requisites:

- 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

Pre-requisites:
- Goldsby,R.A.,Kindt,T.J.,Osborne

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

References:
- 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 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

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

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

Pre-requisites:
- Only BC Students,Biochemistry students,Biochemistry students

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

References:

- 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

References:

- 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 302 (MAY) 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

Pre-requisites:

- 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

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; navigation and communication; 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.

Rohini Balakrishnan, Maria Thaker

References:

- Alcock,J.,Animal Behaviour - An Evolutionary Approach (Sixth Edition),Sinauer Associates,1998
- Neuroethology – J. M. Camhi (1984) Sinauer Associates, Sunderland
- Behavioural Ecology: An Evolutionary Approach. J. R. Krebs & N. B. Davies (1991) Blackwell Press, Oxford
- Sensory Ecology, Behaviour and Evolution by Martin Stevens (2013) Cambridge University Press

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

Pre-requisites:

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

EC 303 (AUG) 2:1

Stochastic and Spatial Dynamics in Biology

This course will cover topics on stochastic and spatial dynamics in biology that will have applications to various topics such as the ecology of species to pattern formation in cellular systems. Tentative topics are: 1) Single-species dynamics accounting for stochasticity and space; using bifurcation theory, reaction-diffusion and integrodifferential equations, Fisher Kolmogorov equations, Fokker-Planck and Langevin equations, etc. 2) Multi-species dynamics. Predator-prey and competition dynamics, etc. 3) Self-organization and pattern formations in biological systems; Turing patterns; swarm dynamics and swarm intelligence (agent-based models; non-equilibrium statistical physics), etc. Concepts of Phase Transitions in Biology.

Vishwesha Guttal

References:

- Gardiner, Stochastic Methods A Handbook for the Natural and Social Sciences, Springer, (Ed 4 in 2009) ISBN 978-3-540-70712-7
- Murray, Mathematical Biology, Springer (Ed 3 in 2002), 978-1-4757-7709-3

Pre-requisites:

- EC 201

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; statistical hypothesis testing; linear models, regression, ANOVA; generalised linear models; statistical modelling strategies

Kavita Isvaran

References:
- Hilborn,R. and Mangel,M., The Ecological Detective: Confronting Models with Data. Princeton University Press, Princeton
- Zuur A, Ieno EN and GM Smith 2007 Analysing ecological data. Springer
- Crawley MJ 2007 The R Book. John Wiley & Sons

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.

Vishwesha Guttal

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

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

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

EC 205 (JAN) 2:0

Multi-omics approaches for biologists

Historically, data collection, particularly at the molecular level, has presented the major bottleneck for the advancement of science. For example, in the early years of DNA sequencing technologies, human genome sequencing incurred expenses in billion US dollars and took more than a decade to complete. In contrast, in the modern era of ‘omics’ technologies, sequencing of a human genome costs less than $1000 and a day for sequencing to assembly. The advent of high-throughput technologies has, similarly, revolutionized numerous fields of biology. ‘Big data’ generated by these approaches offers various opportunities and challenges alike. This course will provide an in-depth knowledge of principles and state-of-the-art practices in ‘omics’ approaches and their application in various fields of biology, including ecology, evolutionary biology, genetics, and biomedical research. This course will consist of lectures, discussions, and hands-on bioinformatic practical sessions, which will introduce students to various aspects of data acquisition, processing, and analyses.

Kartik Sunagar

References:
- Bioinformatics and Functional Genomics, Pevsner (3rd edition)
- Practical Computing for Biologists, Haddock and Dunn
- Primrose SB, Twyman RM (2006). Principles of gene manipulation and genomics. Blackwell Publishing
- Simpson R (2002). Proteins and proteomics: A laboratory manual. Cold Spring Harbor Laboratory Press.

Pre-requisites:
- None

EC 309 (JAN) 2:0

Ecosystems and Global Change

This course will be consist of lectures, readings and discussion, and a final class-project. It will have two 1-hr long sessions every week. In lectures, the instructor will cover topics related to ecosystem ecology, biogeochemical cycles, feedbacks between global change and ecosystem functions. The overall aim will be to introduce the different aspects of global change (e.g., rising CO2, altered precipitation, nutrient deposition, land-use and land-cover change, etc.) and their linkages with ecosystem functions. Through assigned readings, students will develop a broad understanding of how biogeochemistry provides a common premise to understand these linkages. Students will be evaluated upon their performance in a mid-semester exam, and a final class-project. The class-project is envisioned to be a review or synthesis (e.g., meta-analysis of primary literature) of a topic that is relevant to ecosystem ecology or global change.

Sumanta Bagchi

References:
- Schlesinger WH, and E Bernhardt (2013). Biogeochemistry: An analysis of global change. 3rd ed, 688 pp. Academic Press. ISBN 9780123858740

Pre-requisites:
- EC203

Co-requisites:
- None

Molecular Biophysics Unit

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

Pre-requisites:
- Tinoco,I.,Sauer,K.,Wang

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, Mahavir Singh

Pre-requisites:
- 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 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

Pre-requisites:
- 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.

Srinivasan N, Anand Srivastava

Pre-requisites:
- Ramachandran,G.N.,and Sasisekharan,V.,Advances in Protein Chemistry

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

References:

- "Foundations of Cellular Neurophysiology" by Daniel Johnston and Samuel Wu, MIT Press, 1995.
- "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.
- "The Hippocampus Book" by Per Andersen, Richard Morris, David Amaral, Tim Bliss and John O'Keefe. Oxford University Press, 2006.
- "Dendrites" by Greg Stuart, Nelson Spruston and Michael Hausser. Oxford University Press, 2016.
- "Synapses" by W. Maxwell Cowan, Thomas C. Südhof, Charles F. Stevens, The Johns Hopkins University Press, 2003.
- "The synaptic organization of the brain" by Gordon Shepherd, Oxford University Press, 2004.
- "Rhythms of the Brain" by Gyorgy Buzsaki, Oxford University Press, 2006.

MB 305 (AUG) 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

Pre-requisites:

- Protein NMR Spectroscopy: Principles and Practice, Authors -Cavanaugh,J.,Fairbrother,W.J.,Palmer
- Fundamentals of Protein NMR Spectroscopy, Authors - Gordon Rule and Kevin Hutchinns
- Spin Dynamics: Basics of NMR, Author - Malcolm H Levitt
- Understanding NMR Spectroscopy, Author - James Keeler

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

Pre-requisites:

- Lewin, B., Genes X, Oxford.,McWright and Yamamoto, Transcriptional Regulations I and II, Cold Spring Harbor,Ptashne, M., A Genetic Switch, Cell Press.,Ptaschne and Gann, Genes and Signals, Cold Spring, Harbor Laboratory,Selected papers

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, SP Arun

Pre-requisites:

- 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 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

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

Pre-requisites:

- 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

Dept of Microbiology and Cell Biology

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; Origin of cellular life; Biogeography of microbial diversity (is everything everywhere?); Host associated and free-living microbes; Mechanisms of microbial interactions; Causes, consequences, and evolution of physiological heterogeneity in bacterial populations; Bacterial predation, and survival strategies.

Dipshikha Chakravortty, Amit Singh, Samay Ravindra Pande

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

MC 205 (AUG) 2:0

Host-Pathogen interactions - Bacteria, Viruses and Protozoan Parasites

The vertebrate host has evolved numerous mechanisms to shield itself against the onslaught of the myriad pathogens around it. The host uses toll like receptors to recognize pathogens, and deploys effective weapons from its impressive arsenal to eliminate pathogens. This course will utilize multiple host-pathogen pairs as models to demonstrate the innumerable mechanisms utilized by pathogens of viral, bacterial and parasitic origin to subvert the host and enhance their own survival. Secretion systems of bacteria: Type I, II, III, IV, V overview of ABC exporters and importers, Plant Pathogen interactions (Xanthomonas Citrobactor, Erwinia); Virulence gene expression, intracellular pathogenesis; Signaling by the bacterial components; Innate and adaptive immunity to bacterial pathogens; Quorum sensing, biofilm formation and its role in pathogenesis. 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 inflammatory responses of the host seen in poxviruses, inhibition of MHC class I presentation of viral antigens by adenoviruses, inhibition of host secretory pathway by herpes viruses, prevention of phagosome acidification and other macrophage functions by Mycobacterium tuberculosis, antigenic variation and suppression of TH1 responses by protozoan pathogens will all be covered. Viral infectious cycle; Induction, regulation and mechanisms of Antiviral innate Immunity; Strategies of Viral evasion and antagonism of antiviral immunity; Mechanisms of Viral Pathogenesis. Interferon (IFN) is the cornerstone of antiviral innate immunity in mammalian cells. We will discuss detection of viral pathogens as foreign entity by mammalian cells, subsequent Interferon (IFN) induction and signaling, antiviral mechanisms of IFN Stimulated Genes (ISGs), Viral evasion and antagonism of IFN mediated immune response.

Vijaya S, Dipshikha Chakravortty, Shashank Tripathi

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

MC 206 (AUG) 2:0

RNA BIOLOGY

Mechanisms and machinery of transcription in prokaryotes and eukaryotes. RNA splicing and editing. Catalytic RNAs. RNA-protein recognition and interactions. Transcriptional and translational regulation of gene expression. Ribosome heterogeneity. RNA granules and liquid liquid phase separation. mRNA decay in prokaryotes and eukaryotes. RNA modifications. RNA viruses & viroids, and their biology (Negative sense RNA Viruses, Positive Sense RNA Viruses, Retroviruses, Double Stranded RNA Viruses & Viroids). Small RNAs: biogenesis, and their modes of action in regulation of gene expression and chromatin architecture..

Saibal Chatterjee, Purusharth Rajyaguru, Shashank Tripathi

References:

- Flint SJ, Enquist L, Racaniello V, Rall GF, Skalka AM. Principles of Virology. 4th ed. ASM Press; 2015. ISBN-10: 1555819338 Knipe DM, Howley PM . Fields Virology. 6th ed. Lippincott: Williams and Wilkins; 2013. ISBN-10: 1451105630 For general RNA Biology: Any standard text book and The RNA World by Gesteland, Cech, and Atkins

Pre-requisites:

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

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

Nagaraja V, Umesh Varshney, Saibal Chatterjee

Pre-requisites:

- 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. 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. Methods of Genome Editing; ZFN, TALEN and CRISPR/Cas Systems, Genome wide Screening, Gene Drives. Ethical and Safety issues of Genome Editing. Applications of Genetic Engineering Methods in Medicine and Agriculture.

Ajit Kumar P, Shashank Tripathi

References:

- J. Sambrook and D. W. Russell, Molecular Cloning: A Laboratory Manual, 3rd Edn: Vol. I, II, & III, Cold Spring Harbor Laboratory Press. J. J. Greene and V. B. Rao. Recombinant DNA Principles and Methodologies. CRC Press. S. B. Primrose and R. M. Twyman. Principles of Gene Manipulation and Genomics, 7th Edn, Blackwell Publishing. Fred Ausubel and Others. Current Protocols in Molecular Biology. Wiley. Gurbachan S. Miglani, Genome Editing: A Comprehensive Treatise. Alpha Science International Ltd.; CRISPR 101: A Desktop Resource Created and Compiled by Addgene May 2017 (2nd Edition) www.addgene.org. Information will also be taken from the original papers, which describe the principles and methods.

Pre-requisites:

- Basic biology, chemistry and physics

Co-requisites:

- None

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

Pre-requisites:

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

MC 213 (AUG) 2:0

Laboratory Rotations

This is a core course in the first semester for all the Ph.D. students admitted only to the Department of MCB (no option for auditing it). The course involves bench work and academic interactions in the laboratories of three faculty members. The students will learn basic experimental techniques and concepts in the subject area. Rotation in each laboratory will be for 5-6 weeks. Students will write a short work report and make an oral presentation, which will be evaluated and graded by the Faculty mentors and the Coordinator.

Amit Singh

MC 202 (JAN) 2:0

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 eukaryotes and prokaryotes. Some examples are genetic and epigenetic mechanisms of cell fate determination and signaling pathways in development, embryo and organ patterning, regulation of organ size and shape, stem cell homeostasis and developmental plasticity using Drosophila and Arabidopsis as model organisms. Development in unicellular prokaryotes and eukaryotes. Genetics of the evolution of life cycle in the lab.

Utpal Nath, Upendra Nongthomba, Samay Ravindra Pande

References:

- 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 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

References:

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

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

References:

- Principles of Regenerative Biology by Bruce Carlson. http://www.sciencedirect.com/science/book/9780123694393
- Regeneration – Developmental Biology by Scott F Gilbert (6th edition)
- Hand book of the Biology of Aging,Seventh Edition,by Edward J. Masoro,Steven N. Austad,2010
- 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

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

RD 204 (AUG) 2:0

Principles of Signal Transduction in Biological Systems

The course will cover principles of signal transduction and aspects of systemic evaluation of signaling pathways. Detailed analysis of receptors, second messengers and ion channels in various organisms; Methods and techniques of studying signal transduction pathways; signal transduction in bacterial systems and in higher mammalian systems; Mammalian signal transduction mechanisms i GPCRs signaling, MAP kinases, protein kinases, second messenger generating systems, ion channels and other signaling cascades; proteins scaffolding and cellular context will be covered. The course will also cover aspects of studying signal transduction events in living systems using modern microscopic techniques and hos spatio-temporal dynamics of signaling pathways regulate cellular physiology. Genetic analysis of signalling pathways in model organisms.

Deepak Kumar Saini, Ramray Bhat

Pre-requisites:
- Molecular Biology of the Cell by Alberts B et al.,5th Edition,Biochemistry of Signal Transduction and Regulation,Krauss G,5th Edition

RD 210 (AUG) 2:0

Fundamentals of Physiology and Medicine

Ramray Bhat

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

References:

- 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.

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

References:

- 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 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

References:

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

Centre for Neuroscience

NS 201 (AUG) 2:0

Systems Neuroscience

Neuronal biophysics, sensation & perception, motor systems

Aditya Murthy, SP Arun, Supratim Ray

NS 202 (AUG) 2:0

Molecular and Cellular Basis of Behaviour

Neuroanatomy, neurotransmitter systems, synaptic transmission, pre- and post-synaptic organization and its relationship to synaptic physiology, synaptic plasticity, learning and memory.

Balaji J, Deepak Kumaran Nair

NS 203 (AUG) 2:0

Cognitive Neuroscience

Methods in cognitive neuroscience, attention, decision making, executive functions, emotion, reward and motivation.

Sridharan Devarajan, srikant Padmala

NS 204 (AUG) 2:0

Developmental Neuroscience

Basic neuroanatomy of the central and peripheral nervous systems, neurogenesis, cell migration, cellular determination and differentiation, Neuronal growth cone and axon growth, Cell death in the nervous system, synapse formation, refinement of synaptic connections, astrocyte development and functions, oligodendrocyte development and functions, microglia development and functions.

Narendrakumar Ramanan, Kavita Babu

NS 211 (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

NS 301 (JAN) 2:0

Topics in Systems and Cognitive Neuroscience

Critical readings and grant writing on various topics in systems neuroscience.

SP Arun, Supratim Ray, srikant Padmala

Pre-requisites:

- NS201 or NS203

NS 302 (JAN) 2:0

Topics in Molecular and Cellular Neuroscience

Critical reading and grant writing on various topics in molecular and cellular neuroscience

Balaji J, Narendrakumar Ramanan, Deepak Kumaran Nair

Pre-requisites:

- NS 202 or NS204

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.

Chemical Science

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

References:

- 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

References:

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

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

References:

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

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

References:

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

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

References:

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

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

Arunan E

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

References:

- 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

References:

- 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.

Tushar Kanti Chakraborty, Akkattu T Biju

References:

- 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

References:

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

CD 225 (JAN) 0:4

Physical and Analytical Chemistry Laboratory

Langmuir adsorption, chemical analysis by potentiometry, 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.

Shivakumara C, Chinmoy Ranjan

References:

- (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 241 (JAN) 0:14

Research Project

Ravishankar Narayanan

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

References:

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

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

References:

- I. N. Levine, Molecular Spectroscopy
- W. S. Struve, Fundamentals of molecular spectroscopy
- P. F. Bernath, Spectra of atoms and molecules (2nd Ed.)
- F. A. Cotton, Chemical Applications of Group Theory

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

References:

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

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

References:

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

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

References:

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

UC 101 (AUG) 2:1

Physical Principles of Chemistry

Vasudevan S, Upendra Harbola

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

References:

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

IP 321 (JAN) 2:0

Spectroscopy and Astrochemistry

Electromagnetic spectrum, nature, emission and absorption of light, Beer-Lambert Law, rotational, vibrational and rovibrational spectroscopy, electronic spectroscopy. Matter and radiation in the early universe, formation of atoms and molecules, Chemical composition of circumstellar and interstellar objects. Modern techniques of microwave spectroscopy and application to astrochemistry, Buckminsterfullerene, polycyclic aromatic hydrocarbons, interstellar dust and particles. Analytical instruments used on probes and spacecraft, Chemical physics of interfaces, aerosols and its significance for planetary and astro-chemistry.

Arunan E

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

References:

- 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, Chinmoy Ranjan

References:

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

Materials Research Centre

MR 303 (AUG) 3:0

Nanomaterials Synthesis and Devices

Introduction to nanoscience and nanotechnology. Surfaces, interfaces and characterization techniques. Chemical and physical methods of synthesizing nanomaterials (0D, 1D & 2D), Growth mechanisms and growth kinetics, Size-dependent properties of nanomaterials, Applications in catalysis, gas sensing, photodetection and white light emission, Applications in Devices such as linear, rectifier, FET, etc.

Karuna Kar Nanda, Balaram Sahoo

References:

- Markov I. V.,Crystal Growth for Beginners,Fundamentals of Nucleation,Crystal Growth and Epiaxy,World Scientific

MR 304 (AUG) 1:2

Characterization Techniques in Materials Science

Preparation of fine particles, growth of single crystals and thin films, thermal analysis, magnetic measurement, X-ray diffraction, SEM and TEM analyses, electrical and dielectric measurements.

Arun M Umarji

Pre-requisites:

- Faculty,of,MRC

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

References:

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

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

References:

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

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

References:

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

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

References:

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

Organic Chemistry

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, Garima Jindal

Pre-requisites:

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

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, Garima Jindal

Pre-requisites:

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

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

References:

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

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

References:

- 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

References:

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

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

References:

- 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 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

Pre-requisites:
- colloquium

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

Tushar Kanti Chakraborty, Akkattu T Biju

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

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 in organic 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

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

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.

Vasudevan S, Natarajan S

References:

- 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

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

CD 221 (AUG) 3:0

Physical Chemistry-2: Statistical Mechanics

Govardhan P Reddy

References:

- Statistical Mechanics by Donald Allan McQuairre
- Statistical Mechanics for Chemistry and Material Science by Biman Bagchi
- Introduction to Modern Statistical Mechanics by David Chandler
- Thermodynamics by Enrico Fermi

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.

Awadhesh Narayan

Pre-requisites:

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

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.

Anshu Pandey, Vivek Tiwari

Pre-requisites:

- 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

References:

- 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 209 (AUG) 3:0

Electrochemical Systems

A large section of the course will be dedicated to principles of electrochemistry which form the foundation of advanced electrochemical systems. A primer to electrochemical fundamentals will be provided to ensure that the course is self-contained with a minimum of pre-requisites. The course will cover electrochemical systems such as batteries, fuel cells, electrochemical transistors, nanoelectrochemical devices such as memristors and elementary electrolyte theory and its applications to confined nano-scale systems.

Naga Phani B Aetukuri

References:

- Electrochemical Methods: Fundamentals and Applications by Bard and Faulkner
- Electrochemical Systems by Newman and Thomas-Alyea
- Advanced Batteries by Huggins

Pre-requisites:

- The students need to be comfortable with elementary differential and integral calculus and basics of thermodynamics. A prior exposure to electromagnetism may be useful but not necessary.

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

References:

- 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.

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
Chair
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 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

References:

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

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

References:

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

IN 221 (AUG) 3:0

Sensors and Transducers

Electromagnetics, Electromagnetic Sensors , Electrical Machines, Semiconductor fundamentals, MOS capacitor based sensors, FET based sensors, Mechatronics, Microelectromechanical system, Mechanical Transducers, Photonics, Imaging Sensors, Fiber optics, interferometry, Measurements on the Micro and Nanoscale, Fundamental limits on amplifiers, Fabrication of sensors, Photolithography

Atanu Kumar Mohanty, Jayanth G R, Sanjiv Sambandan, Manish Arora, Chandni U, Asha Bhardwaj, Dr. Baladitya Suri

References:

- W. Bolton, Mechatronics, Longman, 2015
- B.E.A. Saleh and M.C.Teich , Fundamentals of Photonics, John Wiley and Sons, 2007
- D. Pozar, Microwave Engineering,John Wiley and Sons, 2012
- Robert F. Pierret, Gerold W. Neudeck, Modular Series on Solid State Devices, Pearson, 1988
- M. J. Madou, Fundamentals of Microfabrication, CRC Press, 2002

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

References:

- 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

References:

- 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
- Aschroft and Mermin, Solid State Physics

Pre-requisites:

- Basic mathematics and Linear Algebra

IN 234 (AUG) 3:0

Biomedical Optics and Spectroscopy

Mathematical Preliminaries: Signal Processing, Probability and Linear Algebra. A brief introduction to medical imaging, basic principles of imaging modalities such as x-ray, CT, SPECT, PET, MRI, Ultrasound. Basics of Spectroscopy: Infrared Spectroscopy, Raman Spectroscopy, Fluorescence Spectroscopy and Optoacoustic spectroscopy. Introduction to biomedical optics, single-scatterer theories, Monte Carlo modelling of photon transport, convolution for broad-beam responses, radiative transfer equation and diffusion theory, hybrid model of Monte Carlo and diffusion theory, sensing of optical properties and spectroscopy, optical coherence tomography basics, diffuse optical tomography, optoacoustic tomography, and ultrasound modulated optical tomography. Spectroscopy in the context of imaging.

Jaya Prakash

References:

- Lihong V. Wang and Hsin-i Wu, Biomedical Optics: Principles and Imaging, Wiley, (2007). ISBN: 978-0-471-74304-0.
- Valery Tuchin, Tissue Optics: Light Scattering Methods and Instruments for Medical Diagnosis, SPIE Press (2007).
- Jerry L. Prince and Jonathan M. Links, Medical Imaging Signals and Systems, Prentice Hall, (2005).

Pre-requisites:

- Signals Processing, Optics, & consent from the instructor

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

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

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

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

IN 302 (AUG) 3:0

Classical and Quantum Optics

Wave Optics and Electromagnetic Theory, Quantum Behaviour of Light, Casimir Effect etc.

Partha Pratim Mondal

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

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

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

References:

- 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 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

References:

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

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

References:

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

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

References:

- 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 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

References:

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

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

References:

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

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.

Dr. Baladitya Suri

References:

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

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

References:

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

IN 299 (JAN) 0:19

Dissertation Project

Dept of Mathematics

Course no.	Credits	Course title	Type
MA 200	3:1	Multivariable Calculus	Core
MA 212	3:0	Algebra I	Core
MA 219	3:1	Linear Algebra	Core
MA 221	3:0	Analysis I: Real Anaysis	Core
MA 231	3:1	Topology	Core
MA 261	3:0	Probability Models	Core
MA 223	3:0	Functional Analysis	Core
MA 232	3:0	Introduction to Algebraic Topology	Core
MA 242	3:0	Partial Differential Equations	Core
MA 216	3:0	Introduction to Graph Theory	Elective
MA 220	3:0	Representation Theory of Finite Groups	Elective
MA 306	3:0	Topics in Morse Theory	Elective
MA 328	3:0	Introduction to Several Complex Variables	Elective
MA 333	3:0	Riemannian Geometry	Elective
MA 341	3:0	Matrix Analysis & positivity	Elective
MA 349	3:0	Topics around the Grothendieck inequality	Elective
MA 361	3:0	Probability Theory	Elective
MA 371	3:0	Control & Homogenization	Elective
MA 395	3:0	Topics in Stochastic Finance	Elective
MA 396	3:0	Large Deviations	Elective
MA 399	2:0	Seminar on topics in Mathematics	Elective

MA 200 (AUG) 3:1

Multivariable Calculus

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

References:
- Rudin, Principles of Mathematical Analysis, McGraw-Hill, 1986.
- B. V. Limaye and S. Ghorpade, A course in Calculus and Real Analysis, Springer
- Spivak, M., Calculus on Manifolds, W.A. Benjamin, co., 1965

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.

Apoorva Khare

References:
- 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.

Pre-requisites:
- UM 203

MA 216 (AUG) 3:0

Introduction to Graph Theory

Graphs, subgraphs, Eulerian tours, trees, matrix tree theorem and Cayley's formula, connectedness and Menger's theorem, planarity and Kuratowski's theorem, chromatic number and chromatic polynomial, Tutte polynomial, the five-colour theorem, matchings, Hall's theorem, Tutte's theorem, perfect matchings and Kasteleyn's theorem, the probabilistic method, basics of algebraic graph theory.

Arvind Ayyer

References:
- Adrian Bondy and U.S.R. Murty, Graph Theory, Graduate Texts in Mathematics, 244. Springer, New York, 2008, ISBN: 978-1846289699.
- Reinhard Diestel, Graph theory (Third edition), Graduate Texts in Mathematics, 173. Springer-Verlag, Berlin, 2005. ISBN: 978-3540261827.
- Douglas B. West, Introduction to graph theory, Prentice Hall, Inc., Upper Saddle River, NJ, 1996. ISBN: 0-13-227828-6.

Pre-requisites:
- No prerequisites are expected, but we will assume a familiarity with linear algebra.

MA 219 (AUG) 3:1

Linear algebra

Fields and linear equations over fields, Vector spaces : Definition, basis and dimension, direct sums. Linear transformations: definition, the Rank-Nullity Theorem, the algebra of linear transformations. Dual spaces. Determinants. Eigenvalues and Eigenvectors, the characteristic polynomial, the Cayley-Hamilton Theorem, the minimal polynomial, and algebraic and geometric multiplicities. Diagonalization. The Jordan canonical form. 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. Singular value decomposition. Tensor products and exterior algebra.

Vamsi Pritham Pingali

References:

- 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.
- Lang S. Linear Algebra (3rd Ed.) Springer-Verlag (UTM). 1989.

Pre-requisites:

- UM 102

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 SU(2)

Pooja Singla

References:

- 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.
- J. P. Serre. Graduate Texts in Mathematics. Vol. 42. Springer-Verlag. New York-Heidelberg. 1977

Pre-requisites:

- MA 219, MA 212

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.

Gadadhar Misra

References:

- 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 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.

Thangavelu S

References:

- John Conway A Course in Functional Analysis (Springer),Rajendra Bhatia Notes On Functional Analysis Texts and Readings in Mathematics (Hindustan Book Agency 2009)
- Rudin, Functional Anaysis (2nd Ed.), McGraw-Hill, 2006.
- Yosida, K., Functional Anaysis (4th Edition), Narosa, 1974.
- Goffman, C. and Pedrick, G., First Course in Functional Analysis, Prentice-Hall of India, 1995.

Pre-requisites:

- MA 222, MA 224, MA 219

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.

Subhojoy Gupta

References:

- Armstrong, M. A., Basic Topology, Springer (India), 2004., Functional Anaysis (2nd Ed.), McGraw-Hill, 2006.
- Munkres, K. R., Topology,Pearson Education, 2005, Functional Anaysis (4th Edition), Narosa, 1974.
- Viro, O.Ya., Ivanov, O.A., Netsvetaev, N., and Kharlamov, V.M., Elementary Topology: Problem Textbook, AMS, 2008.

MA 232 (AUG) 3:0

Introduction to Algebraic Topology

The fundamental group: Homotopy of maps, multiplication of paths, the fundamental group, induced homomorphisms, the fundamental group of the circle, covering spaces, lifting theorems, the universal covering space, Seifert-van Kampen theorem, applications. Simplicial Homology: Simplicial complexes, chain complexes, definitions of the simplicial homology groups, properties of homology groups, applications.

Siddhartha Gadgil

References:

- Allen Hatcher Algebraic topology. Cambridge University Press. Cambridge. 2002.
- Armstrong, M.A., Basic Topology, Springer (India), 2004.
- William S. Massey A basic course in algebraic topology. Graduate Texts in Mathematics. 127. Springer-Verlag. New York. 1991.

Pre-requisites:

- MA 231, MA 212

MA 242 (AUG) 3:0

Partial Differential Equations

First order partial differential equation and Hamilton-Jacobi equations; Cauchy problem and classification of second order equations, Holmgren's uniqueness theorem; Laplace equation; Diffusion equation; Wave equation; Some methods of solutions, Variable separable method.

Thirupathi Gudi

References:

- Garabedian, P. R., Partial Differential Equations, John Wiley and Sons, 1964.
- Fritz John, Partial Differential Equations, Springer (International Students Edition), 1971.
- Renardy, M. and Rogers, R. C., An Introduction to Partial Differential Equations, Springer-Verlag, 1992.
- Prasad. P. and Ravindran, R., Partial Differential Equations, Wiley Eastern, 1985.

Pre-requisites:

- MA 241

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.

Arvind Ayyer

References:

- Ross,S.M.,Introduction to Probability Models,Academic Press 1993.,Taylor
- Taylor, H.M., and Karlin, S., An Introduction to Stochastic Modelling, Academic Press, 1994.

MA 306 (AUG) 3:0

Topics in Morse Theory

Transversality, Morse functions, stable and unstable manifolds, Morse-Smale moduli spaces, the space of gradient flows, compactification of the moduli spaces of flows, Morse homology, applications.

Arun Maiti

References:

- Michèle Audin, Mihai Damian, Morse Theory and Floer Homology, 2014, Springer-Verlag London.
- J. Milnor, Morse Theory, Ann. of Math. Stud. 51, Princeton Univ. Press, Princeton, 1963.
- L. Nicolescu, An invitation to Morse theory, http://www3.nd.edu/
- lnicolae/Morse2nd.pdf.
- M. Schwarz, Morse homology, Birkhäuser, Basel, 1993.
- R. Cohen, Kevin Iga, Paul Norbury, Topics in morse theory, lecture notes, 2006.

Pre-requisites:

- MA 232, MA 338

MA 328 (AUG) 3:0

Introduction to Several Complex Variables

Preliminaries: Holomorphic functions in Cn : definition , the generalized Cauchy integral formula, holomorphic functions: power series development(s), circular and Reinhardt domains, analytic continuation : basic theory and comparisons with the one- variable theory. Convexity theory: Analytic continuation: the role of convexity, holomorphic convexity, plurisub-harmonic functions, the Levi problem and the role of the d-bar equation. The d- bar equation: Review of distribution theory, Hormander's solution and estimates for the d-bar operator.

Gautam Bharali

References:

- Lars Hormander, An Introduction to Complex Analysis in Several Variables, 3rd edition, North-Holland Mathematical Library, North-Holland, 1989.
- Function Theory of Several Complex Variables, 2nd edition, Wadsworth & Brooks/Cole, 1992.
- Raghavan Narasimhan, Several Complex Variables, Chicago Lectures in Mathematics Series, The University of Chicago Press, 1971.

MA 333 (AUG) 3:0

Riemannian Geometry

Review of differentiable manifolds and tensors, Riemannian metrics, Levi-Civita connection, geodesics, exponential map, curvature tensor, first and second variation formulas, Jacobi fields, conjugate points and cut locus, Cartan-Hadamard and Bonnet Myers theorems. Special topics - Comparison geometry (theorems of Rauch, Toponogov, Bishop-Gromov), and Bochner techniques.

Ved V Datar

References:

- Sylvestre Gallot, Dominique Hulin, Jacques Lafontaine, Riemannian geometry, Third edition., Universitext. Springer-Verlag, Berlin, 2004.
- Peter Petersen, Riemannian geometry, Graduate Texts in Mathematics, 171. Springer-Verlag, New York, 1998.
- John Lee, Riemannian Geometry - An introduction to curvature, Graduate Texts in Mathematics, 176. Springer-Verlag, New York, 1997.

MA 341 (AUG) 3:0

Matrix Analysis and Positivity

This course explores matrix positivity and operations that preserve it. These involve fundamental questions that have been extensively studied over the past century, and are still being studied in the mathematics literature, including with additional motivation from modern applications to high-dimensional covariance estimation. The course will bring together techniques from different areas: analysis, linear algebra, combinatorics, and symmetric functions. List of topics (time permitting): 1. The cone of positive semidefinite matrices. Totally positive/non-negative matrices. Examples of PSD and TP/TN matrices (Gram, Hankel, Toeplitz, Vandermonde, P G). Matrix identities (Cauchy-Binet, Andreief). Generalized Rayleigh quotients and spectral radius. Schur complements. 2. Positivity preservers. Schur product theorem. Polya-Szego observation. Schoenberg's theorem. Positive definite functions to correlation matrices. Rudin's (stronger) theorem. Herz, Christensen-Ressel. 3. Fixed-dimension problem. Introduction and modern motivations. H.L. Vasudeva's theorem and simplifications. Roger Horn's theorem and simplifications. 4. Proof of Schoenberg's theorem. Characterization of (Hankel total) positivity preservers in the dimension-free setting. 5. Analytic/polynomial preservers – I. Which coefficients can be negative? Bounded and unbounded domains: Horn-type necessary conditions. 6. Schur polynomials. Two definitions and properties. Specialization over fields and for real powers. First-order approximation. 7. Analytic/polynomial preservers – II. Sign patterns: The Horn-type necessary conditions are best possible. Sharp quantitative bound. Extension principle I: dimension increase. 8. Entrywise maps preserving total positivity. Extension principle II: Hankel TN matrices. Variants for all TP matrices and for symmetric TP matrices. Matrix completion problems. 9. Entrywise powers preserving positivity. Application of Extension principle I. Low-rank counterexamples. Tanvi Jain's result. 10. Characterizations for functions preserving P G . Extension principle III: pendant edges. The case of trees. Chordal graphs and their properties. Functions and powers preserving P G for G chordal. Non-chordal graphs.

Apoorva Khare

References:
- Rajendra Bhatia, Matrix Analysis, vol. 169 of Graduate Texts in Mathematics, Springer, 1997.
- Rajendra Bhatia, Positive definite matrices, Princeton Series in Applied Mathematics, 2007.
- Roger A. Horn and Charles R. Johnson, Matrix analysis, Cambridge University Press, 1990.
- Roger A. Horn and Charles R. Johnson, Topics in matrix analysis, Cambridge University Press, 1991.
- Samuel Karlin, Total positivity, Stanford University Press, 1968.

Pre-requisites:
- MA 219

Co-requisites:
- A course in Linear Algebra and Calculus/Real Analysis

MA 349 (AUG) 3:0

Topics around the Grothendieck inequality

Banach-Mazur distance, 2 - summing norm, CUT norm, Tensor product norm (projective and injective), Grothendieck inequality, Operator space structure (MIN and MAX), contractive and completely contractive maps, Applications.

Gadadhar Misra

References:
- Summing and Nuclear Norms in Banach Space Theory, G. J.O. Jameson, London Mathematical Society (Student Texts)
- Completely Bounded Maps and Operator Algebras, V. I. Paulsen, Cambridge University Press
- Alice and Bob Meet Banach: The Interface of Asymptotic Geometric Analysis and Quantum Information Theory, Guillaume Aubrun, Stanislaw J. Szarek, Mathematical Surveys and Monographs Volume: 223; 2017

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.

Manjunath Krishnapur

References:
- Durrett, R., Probability: Theory and Examples (4th Ed.), Cambridge University Press, 2010.
- Billingsley, P., Probability and Measure (3rd Ed.), Wiley India, 2008.
- Walsh, J., Knowing the Odds: An Introduction to Probability, AMS, 2012.
- Kallenberg, O., Foundations of Modern Probability (2nd Ed.), Springer-Verlag, 2002.

Pre-requisites:
- MA 222

MA 371 (AUG) 3:0

Control and Homogenization

Optimal Control of PDE:Optimal control problems governed by elliptic equations and linear parabolic and hyperbolic equations with distributed and boundary controls, Computational methods. Homogenization:Examples of periodic composites and layered materials. Various methods of homogenization. Applications and Extensions:Control in coefficients of elliptic equations, Controllability and Stabilization of Infinite Dimensional Systems, Hamilton- Jacobi-Bellman equations and Riccati equations, Optimal control and stabilization of flow related models.

Nandakumaran A K

References:

- B. Lee and L. Markus, Foundations of Optimal Control Theory, John Wiley, 1968.
- L. Lions, Optimal Control of Systems Governed by Partial Differential Equations, Springer, 1991.
- L. Lions, Controlabilite exact et Stabilisation des systemes distribues, Vol. 1, 2 Masson, Paris, 1988.
- Bardi, I. Capuzzo-Dolcetta, Optimal Control and Viscosity Solutions of Hamilton-Jacobi-Bellman Equations, Birkhauser, 1997. Kesavan, Topics in Functional Analysis and Applications, Wiley-Eastern, New Delhi, 1989. Dal Maso, An Introduction to G - Convergence, Birkhauser, 1993.
- Kesavan, Topics in Functional Analysis and Applications, Wiley-Eastern, New Delhi, 1989. Dal Maso, An Introduction to G - Convergence, Birkhauser, 1993.
- Dal Maso, An Introduction to G -Convergence, Birkhauser, 1993.

Pre-requisites:

- Sobolev spaces
- Elliptic boundary value problems Heat and wave equations Variational formulation and semigroup theory
- Heat and wave equations
- Variational formulation and semigroup theory

MA 395 (AUG) 3:0

Topics in Stochastic Finance

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. Investment portfolio: Markovitz's diversification. Capital asset pricing model(CAPM). Utility theory. 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. Forward LIBOR model.

Mrinal Kanti Ghosh

References:

- Luenberger, D. V., Investment Science, Oxford University Press, 1998.
- Roman, S., Introduction to the Mathematics of Finance, Springer, 2004.
- Shiryaev, A. N., Essentials of Stochastic Finance, World Scientific, 1999.
- Shreve, S. E., Stochastic Calculus for Finance I: The Binomial Asset Pricing Model, Springer, 2004.
- Shreve, S. E., Stochastic Calculus for Finance II: The Continuous Time Models, Springer, 2004.

Pre-requisites:

- MA 261 or equivalent

MA 396 (AUG) 3:0

Large Deviations

Large deviations provide quantitative estimates of the probabilities of rare events in (high-dimensional) stochastic systems. The course will begin with general foundations of the theory of large deviations and will cover classical large deviations techniques. In the latter part of the course some recent developments, such as large deviations in the context of random graphs and matrices, and its application in statistical physics will be discussed.

Thangavelu S

References:

- Amir Dembo and Ofer Zeitouni, Large Deviations Techniques and Applications.
- Firas Rassoul-Agha and Timo Seppalainen, A Course on Large Deviations with an Introduction to Gibbs Measures.
- Marc Mezard and Andrea Montanari. Information, Physics, and Computation.
- Sourav Chatterjee. Large Deviations for Random Graphs.

Pre-requisites:

- This is a graduate level topics course in Probability theory. Graduate level measure theoretic probability will be useful, but not a requirement. The course will be accessible to advanced undergraduates who have had sufficient exposure to probability.

MA 399 (AUG) 2:0

Seminar on topics in Mathematics

Vamsi Pritham Pingali

MA 201 (JAN) 7:0

Project

Manjunath Krishnapur

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

Pre-requisites:

- 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 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

Pre-requisites:

- 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 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

References:

- 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.

Pre-requisites:

- MA 221

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

Pre-requisites:

- 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

Pre-requisites:

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

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

References:

- 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.

Janaki B

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 E x t and T o r for sheaves Serre duality theorem Schemes as functors of points, the idea of stacks

Abhishek Banerjee

References:

-
- 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 316 (JAN) 3:0

Introduction to Homological Algebra

Polynomial ring, Projective modules, injective modules, flat modules, additive category, abelian category, exact functor, adjoint functors, (co)limits, category of complexes, snake lemma, derived functor, resolutions, Tor and Ext, dimension, local cohomology,group (co)homology, sheaf cohomology, Cech cohomology, Grothendieck spectral sequence, Leray spectral sequence.

Safdar Quddus

References:
- Cartan and Eilenberg, Homological Algebra
- Weibel, Introduction to Homological Algebra
- Rotman, Introduction to Homological Algebra

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

References:
- 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 326 (JAN) 3:0

Fourier Analysis

Introduction to Fourier Series; Plancherel theorem, basis approximation theorems, Dini's Condition etc. Introduction to Fourier transform; Plancherel theorem, Wiener-Tauberian theorems, Interpolation of operators, Maximal functions, Lebesgue differentiation theorem, Poisson representation of harmonic functions, introduction to singular integral operators.

Narayanan E K

Pre-requisites:
- 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 327 (JAN) 3:0

Topics in analysis

Several important results in Analysis will be stated and proved, with emphasis on the techniques. Some of the topics that will be covered are: Isoperimetric inequality. Weyl's equidistribution theorems. Uncertainty, principles in harmonic analysis. Bieberbach's conjecture for univalent functions. Maximal functions and their applications. Matching theorem and its applications. Trigonometric series and Brownian motion. Discrete analysis (Laplacian on graphs). Orthogonal polynomials. Asympotics of integrals.

Manjunath Krishnapur

Pre-requisites:
- MA 223
- MA 224
- Rudin W., Real and Complex Analysis (3rd Edition) ,Tata McGraw Hill Education, 2007
- Korner, I. T. W., Fourier Analysis (1st Ed.) ,Cambridge Univ., Press, 1988
- N. G. De Bruijn, Asymptotic Methods in Analysis. Dover Publications, 1981

MA 332 (JAN) 3:0

Algebraic Topology

Arun Maiti

Pre-requisites:
- MA 232
- Rotman, J, An Introduction to Algebraic Topology ,Graduate Texts in Mathematics, 119, Springer-Verlag, 198
- Munkres, I. R., Elements of Algebraic Topology ,Addison-Wesiley, 1984
- Shastri, A. R., Basic Algebraic Topology ,CRC Press, 2014

MA 338 (JAN) 3:0

Differentiable manifolds and Lie groups

Differentiable manifolds, differentiable maps, regular values and Sard's theorem, submersions and immersions, tangent and cotangent bundles as examples of vector bundles, vector fields and flows, exponential map, Frobenius theorem, Lie groups and Lie algebras, exponential map , tensors and differential forms, exterior algebra, Lie derivative, Orientable manifolds, integration on manifolds and Stokes Theorem . Covariant differentiation, Riemannian metrics, Levi-Civita connection, Curvature and parallel transport, spaces of constant curvature.

Harish Seshadri

Pre-requisites:
- MA 219, MA 231
- Spivak M., A comprehensive introduction to differential geometry (Vol. 1) (3rd Ed.) ,Publish or Perish, Inc., Houston, Texas, 2005
- Kumaresan S., A course in differential geometry and Lie groups ,Texts and Readings in Mathematics, 22. Hindustan Book Agency, New Delhi, 2002.
- Warner F., Foundations of differentiable manifolds and Lie groups ,Graduate Texts in Mathematics, 94. Springer-Verlag, New York-Berlin, 1983.
- Lee J., Introduction to smooth manifolds ,Graduate Texts in Mathematics, 218., Springer, New York, 2013.

MA 343 (JAN) 3:0

Complex analytic techniques in Operator Theory

Ando dilation of a commuting pair of contractions, Distinguished varieties of the bidisc, Description of all distinguished varieties, Construction of a distinguished variety corresponding to a pair of commuting matrices, Sharpening of Ando's inequality, Extending the sharpened Ando inequality to operators with finite dimensional defect spaces, The extension property, Holomorphic retracts.

Bhattacharyya T

Pre-requisites:
- MA 223
- T. Ando, On a pair of commutative contractions ,Acta Sci. Math. (Szeged) 24 (1963) 88–90.
- Agler, Jim and McCarthy, John E., Distinguished varieties. ,Acta Math. 194 (2005), no. 2, 133–153
- Das, B. Krishna and Sarkar, Jaydeb, Ando dilations, von Neumann inequality, and distinguished varieties. ,J. Funct. Anal. 272 (2017), no. 5, 2114–2131.

MA 362 (JAN) 3:0

Stochastic Processes

First Construction of Brownian Motion, convergence in C [0 , 8) , D [0 , 8) , Donsker's invariance principle, Properties of the Brownian motion, continuous-time martingales, optional sampling theorem, Doob-Meyer decomposition, stochastic integration, Ito's formula, martingale representation theorem, Girsanov's theorem, Brownian motion and the heat equation, Feynman- Kac formula, diffusion processes and stochastic differential equations, strong and weak solutions, martingale problem.

Srikanth Krishnan Iyer

Pre-requisites:

- MA 361
- P. Billingsley, Convergence of probability measures
- Karatzas and Shreve, Brownian motion and stochastic calculus
- Revuz and Yor, Continuous martingales and Brownian motion
- A. Oksendal, Introduction to stochastic differential equations

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

Pre-requisites:

- 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 384 (JAN) 3:0

Mathematical Physics

The purpose of this course will be to understand (to an extent) and appreciate the symbiotic relationship that exists between mathematics and physics. Topics to be covered can vary but those in this edition include: a brisk introduction to basic notions of differential geometry (manifolds, vector fields, metrics, geodesics, curvature, Lie groups and such), classical mechanics (Hamiltonian and Lagrangian formulations, n-body problems with special emphasis on the n=3 case) and time permitting, an introduction to integrable systems.

Kaushal Verma

References:

- Abraham and Marsden, Foundations of Mechanics ,AMS Chelsea
- V. I. Arnold, Mathematical Methods of Classical Mechanics ,Springer, Graduate texts in mathematics 60
- T. Frankel, The geometry of physics ,Cambridge Univ Press 2012.
- H. Goldstein, Classical Mechanics ,Addison-Wesley.
- Hitchin, Segal and Ward, Integrable systems ,Oxford Univ Press

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

Pre-requisites:

- 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 393 (JAN) 3:0

Topics in random discrete structures

Real trees, the Brownian continuum random tree, phase transition in random graphs, scaling limits of discrete combinatorial structures, random maps, the Brownian map and its geometry

Sanchayan Sen

Pre-requisites:

- MA 361
- Jim Pitman, Combinatorial stochastic processes ,Lecture Notes in Mathematics, vol. 1875, Springer-Verlag, Berlin (2006)
- Jean-François Le Gall, Random trees and applications ,Probability Surveys (2005)
- Grégory Miermont, Aspects of random maps ,Saint-Flour lecture notes (2014)

MA 399 (JAN) 2:0

Seminar in Topics in Mathematics

Kaushal Verma

MA 213 (MAY) 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

Pre-requisites:

- 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 222 (MAY) 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

Pre-requisites:

- 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.

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 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

References:

- 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.

Manish Jain

Pre-requisites:

- 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

Sumilan Banerjee

Pre-requisites:

- 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

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

PH 211 (AUG) 0:3

General Physics Laboratory

Identification of NaCl monocrystals using x-ray diffraction, Gamma ray absorption with MCA (calibration and attenuation coefficient), Nuclear Magnetic Resonance (find the magnetogyric ratio of Hydrogen and Fluorine), Velocity of sound in liquids (Raman-Nath experiment), Normal modes in 3D Acoustic Resonant Chamber, Solar Cell (I-V characterization), UV-VIS spectroscopy (Band gap of semiconductor and insulator, thickness measurement), Elastic Plastic deformation of metal wire, X-ray Fluorescence with MCA, Rutherford Scattering

Victor Suvisesha Muthu D, Vasant Natarajan, Srimanta Middey

Pre-requisites:
- practical course,practical course,practicals

PH 213 (AUG) 0:4

Advanced Experiments in Condensed matter physics

Sputtering, PLD, MBE, XRD, XRR, XPS, VSM, Resistivity, DSC, TGA/DTA, etc.

Ganesan R, Anil Kumar P S

Pre-requisites:
- 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

Sudhir Kumar Vempati

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

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.

Prateek Sharma

Pre-requisites:
- Choudhuri,A.R.,Astrophysics for Physicists,Shu,F.

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

Pre-requisites:
- practical course,practical course,practical course

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

Pre-requisites:
- 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

Subroto Mukerjee

Pre-requisites:
- Ashcroft,N.W.,and Mermin,N.D.,Solid State Physics

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

Pre-requisites:
- Chaikin,P.M.,and Lubensky,T.C.,Principles of Condensed Matter Physics

PH 330 (AUG) 0:3

Advanced Independent Project

Open to research students only

Pre-requisites:
- Project Course,Project Course,Project Course

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 360 (AUG) 3:0

Biological Physics

Outline * the living state as a physicist sees it * what a cell contains * noise and biological information * random walks, Brownian motion, diffusion * fluid flow in cell and microbe biology * entropic forces, electrostatics, chemical reactions, self-assembly * macromolecules: statistics, forces, folding, melting * molecular machines * electrical transport across membranes: neurons, nerve impulses * cell membrane mechanics: elasticity, order, shape, dynamics * the cytoskeleton and cell mechanics * collective motility

Sriram Ramaswamy

Pre-requisites:
- Mechanics and Statistical physics at 1st-year graduate student level

PH 362 (AUG) 2:0

Radiative Processess in Astrophysics

Elements of radiative transfer and stellar atmospheres. Theory of grey atmospheres. Covariant formulation of classical electrodynamics. Radiation from accelerated charges. Cyclotron and synchrotron radiation. Bremsstrahlung. Thomson and Compton scattering. Plasma effects. Atomic and molecular spectra. Transition rates and selection rules. Opacity calculations. Line formation in stellar atmospheres.

Prateek Sharma

Pre-requisites:

- Rybicki, G.B. and Lightman, A.P.,Radiative Processes in Astrophysics,Mihalas, D.: Stellar Atmospheres

PH 363 (AUG) 2:0

Introduction to Fluid Mechanics and Plasma Physics

Boltzmann equation. Derivation of fluid equations. An introduction to stellar dynamics. Important properties of ideal and viscous fluid flows. Gas dynamics. Waves in fluids. Hydrodynamics stability. Turbulence. Plasma orbit theory. Debye shielding and collective behaviour. Waves and oscillations inplasmas. From the Vlasov equation to MHD equations. Flux freezing. MHD waves. Reconnection andrelaxation. Dynamo theory.

Rajeev Kumar Jain

Pre-requisites:

- Choudhuri, A.R.: The Physics of Fluids and Plasmas.,Landau, L.D. and Lifshitz, E.M.: Fluid Mechanics. Chen, F.F.: Introduction to Plasma Physics,V.Krishan, Atrophysical Plasmas and Fluids, Kluwer

PH 391 (AUG) 3:0

Quantum Mechanics III

Apoorva Patel

PH 392 (AUG) 3:0

Standard model particle physics

Aninda Sinha

PH 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. Klein-Gordon and Dirac equations. Discrete symmetries: P,C,T. S-matrix, LSZ reduction formula. Interacting scalar and Yukawa theories. Scattering cross-sections, optical theorem, decay rates. Loop diagrams, power counting, divergences. Renormalization, fixed point classification. One loop calculations. Callan-Symanzik equations, beta functions. Effective field theory.

Prasad Satish Hegde

Pre-requisites:

- PHY 203 Quantum Mechanics I
- PHY 204 Quantum Mechanics II

Co-requisites:

- PHY 201 Classical Mechanics

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.

Chethan Krishnan

References:

- 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 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

References:

- 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 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

References:

- 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 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.

Aveek Bid, Srimanta Middey

References:

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

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).

Pre-requisites:

- Project Course,Project Course,Project Course

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 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

References:

- 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 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

Pre-requisites:

- Basic courses in statistical physics, quantum mechanics,Basic courses in statistical physics, quantum mechanics,Basic courses in statistical physics, quantum mechanics

PH 340 (JAN) 3:0

Quantum Statistical Field Theory

Subroto Mukerjee

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

Ramesh Chandra Mallik

References:

- 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 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

References:

- 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 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

References:

- Delerue,C and Lannoo,M.,Nanostructures: Theory and Modelling,Springer

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.

Tanmoy Das

Pre-requisites:

- “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 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

References:

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

PH 366 (JAN) 3:0

Physics of Advanced Optical Materials

Syllabus: Introduction to novel optical materials; Quantum dots, plasmonic nanoparticles, two dimensional materials, metamaterials, photonic crystals; Fundamental excitations is optical materials and their interactions; weak (Purcell) and strong coupling (Rabi) – classical and quantum treatments; wave optics; Fourier optics and microscopy; Maxwell's electromagnetic waves; resonators; quantum theory of photons; light-matter interaction; optical and optofluidic forces in colloidal materials; Advanced experimental techniques to probe optical materials – steady state and time resolved measurements; super-resolution techniques; optical tweezers; anti-bunching and photon correlations.

Jaydeep Kumar Basu, Ambarish Ghosh

References:

- Recommended Books: 1.Principles of Nano Optics, Lukas Novotny and Bert Hecht 2.Optical Metamaterials: Fundamentals and Applications, Wenshan Cai and Vladimir Shalaev. 3.Introduction to Photonic Crystals, JD Joannoupoulos. 4.Quantum Optics, Girish S Agarwal 5.Light-Matter Interaction: Physics and Engineering at the Nanoscale, John Weiner and Frederico Nunes 6.Introduction to Nanophotonics, Sergiy V Gaponenko. 7Semiconductor Quantum Dots, L Banyai and SW Koch

Pre-requisites:

- QM-I and QM-II; Solid State Physics; Introduction to Photonics; Electromagnetic theory; or equivalent courses.

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

References:

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

PH 377 (JAN) 2:0

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

References:

- 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 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.

Ananthanarayan B

Pre-requisites:

- 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 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.

Justin Raj David

References:

- 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 206 (MAY) 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

References:

- 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 250B (MAY) 0:6

Project

Arindam Ghosh

Centre for High Energy Physics

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.

Sudhir Kumar Vempati

References:

- 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

Pre-requisites:

- PHY 204 Quantum Mechanics II

HE 386 (AUG) 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.

Jyothsna Rani Komaragiri

References:

- 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.

Co-requisites:

- HE 215 Nuclear and Particle Physics

HE 389 (AUG) 3:0

AdS/CFT -or- Quantum Gravity in Anti-de Sitter Space

The role of boundaries in quantum gravity: black holes and holography. CFT and AdS preliminaries. Large-N gauge theories. Large-N CFT as AdS quantum gravity. The AdS/CFT dictionary: Euclidean and Lorentzian. Black holes in AdS: deconfinement vs Hawking-Page. What makes the correspondence compelling. The spectrum of AdS/CFT.String theory origins and Maldacena's original version of the conjecture, AdS3/CFT2, Bulk locality and reconstruction.

Chethan Krishnan

References:
- Maldacena J. M. et al: Large N field theories, string theory and gravity: Phys.Rept. 323 (2000) 183-386

Pre-requisites:
- HE 395 Quantum Field Theory I

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

References:
- 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 322 (JAN) 3:0

QCD and Collider Physics

Deep inelastic scattering, parton model.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 dimensions and dark matter. Statistical analysis and limit setting.

Biplob Bhattacherjee

References:
- 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

Pre-requisites:
- HE 395 Quantum Field Theory I

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.

Apoorva Patel

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

HE 396 (JAN) 3:0

Quantum Field Theory II

Abelian gauge theories. QED processes and symmetries. Gauge invariance, covariant derivatives, massless photons, Ward identity. 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.

Ananthanarayan B

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

Pre-requisites:
- HE 395 Quantum Field Theory I

HE 397 (JAN) 3:0

The Standard Model of Particle Physics

Fermions coupled to gauge fields. Tree-level QED processes. 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.

Aninda Sinha

References:
- Halzen F. and Martin A.D., Quarks and Leptons: An Introductory Course in Modern Particle Physics, John Wiley & Sons, 1984
- Georgi H.,Weak Interactions and Modern Particle Theory,Benjamin/Cummings,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

Pre-requisites:
- HE 395 Quantum Field Theory I

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

References:

- 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

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 (ESE), and Electrical Engineering (EE). The courses offered in these departments have been grouped into the following 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 the departments in 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)
M Tech in Communication and Networks (ECE)
M Tech in Computer Science and Engineering (CSA)
M Tech in Electronics Systems Engineering (ESE)
M Tech in Artificial Intelligence (CSA,ECE,EE,ESE)
M Tech in Signal Processing (EE and ECE)
M Tech in Microelectronics and VLSI Design (ECE and ESE)

Prof. Y Narahari
Chair,
Division of EECS

Department of Computer Science and Automation

M.Tech Program

M.Tech students are expected to take a minimum of two courses from each of the three pools - Pool A, Pool B, and Pool C, during the course of their program.

Aug-Dec 2019

Duration: 2 years			**Total Credits: 64**
Soft Core Courses (Pool A, Pool B, Pool C):			
Pool A			
E0 222	3:01	Aug	Automata Theory and Computability
E0 225	3:01	Aug	Design and Analysis of Algorithms
E0 229	3:01	Aug	Foundations of Data Science
E0 235	3:01	Aug	Cryptography
Pool B			
E0 227	3:01	Aug	Program Analysis and Verification
E0 243	3:01	Aug	Computer Architecture
E0 254	3:01	Aug	Network and Distributed Systems Security
E0 256	3:01	Aug	Theory and Practice of Computer Systems Security
E0 271	3:01	Aug	Graphics and Visualization
Pool C			
E0 226	3:01	Aug	Linear Algebra and Probability
E0 230	3:01	Aug	Computational Methods of Optimization
E0 267	3:01	Aug	Soft Computing
Electives:			
E0 251	3:01	Aug	Data Structures and Algorithms
E0 311	3:01	Aug	Topics in Combinatorics
E0 312	3:01	Aug	Foundations of Secure Computation
E0 334	3:01	Aug	Deep Learning for Natural Language Processing
E0 337	3:01	Aug	Topics in Advanced Cryptography
E0 358	3:01	Aug	Advanced Techniques in Compilation and Programming for Parallel Architectures
E0 399	1:02	Aug	Research in Computer Science

January – April 2020

Pool A			
E0 228	3:01	Jan	Combinatorics
E0 244	3:01	Jan	Computational Geometry and Topology
E0 248	3:01	Jan	Theoretical Foundations of Cryptography
E0 249	3:01	Jan	Approximation Algorithms
Pool B			
E0 210	3:01	Jan	Dynamic Program Analysis: Algorithms and Tools
E0 253	3:01	Jan	Operating Systems
E0 255	3:01	Jan	Compiler Design
E0 261	3:01	Jan	Database Management Systems
E0 264	3:01	Jan	Distributed Computing Systems
E0 272	3:01	Jan	Formal Methods in Software Engineering
Pool C			
E0 238	3:01	Jan	Intelligent Agents
E0 268	3:01	Jan	Practical Data Science
E0 270	3:01	Jan	Machine Learning
E1 254	3:01	Jan	Game Theory
E1 277	3:01	Jan	Reinforcement Learning
Electives			
E0 304	3:01	Jan	Computational Cognitive Neuroscience
E0 305	3:01	Jan	Blockchain and Its Applications
E0 338	3:01	Jan	Topics in Security and Privacy
E0 307	3:01	Jan	Program Synthesis meets Machine Learning
E0 399	1:02	Jan	Research in Computer Science
E1 313	3:01	Jan	Topics in Pattern Recognition

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

Pre-requisites:

- Basic knowledge of programming in C/C++/Java.

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.

Anand Louis, Arindam Khan

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 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 229 (AUG) 3:1

Foundations of Data Science

High Dimensional Geometry, SVD and applications, Random Graphs, Markov Chains, Algorithms in Machine Learning, Clustering, Massive data and Sampling on the fly

Siddharth Barman

References:

- Foundations of Data Science by Blum, Hopcroft, and Kannan

Pre-requisites:

- Basic Linear Algebra, Probability, and Algorithms

E0 230 (AUG) 3:1

Computational Methods of Optimization

Need for unconstrained methods in solving constrained problems. Necessary conditions of unconstrained optimization, Structure of methods, quadratic models. Methods of line search, Armijo-Goldstein and Wolfe conditions for partial line search. Global convergence theorem, Steepest descent method. Quasi-Newton methods: DFP, BFGS, Broyden family. Conjugate-direction methods: Fletcher-Reeves, Polak-Ribierre. Derivative-free methods: finite differencing. Restricted step methods. Methods for sums of squares and nonlinear equations. Linear and Quadratic Programming. Duality in optimization.

Chiranjib Bhattacharyya

References:

- Fletcher R., Practical Methods of Optimization, John Wiley, 2000.

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

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

Pre-requisites:

- 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 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

References:

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

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

Pre-requisites:
- Knowledge of Java is desirable,but not necessary.

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

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

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, 2013.

Pre-requisites:

- Undergraduate courses in data structures, algorithms, programming, and linear algebra.

E0 311 (AUG) 3:1

Topics in Combinatorics

Tools from combinatorics is used in several areas of computer science. This course aims to teach some advanced techniques and topics in combinatorics. In particular, we would like to cover probabilistic method which is not covered in the introductory course `graph theory and combinatorics'. Moreover the course would aim to cover to some extent the linear algebraic methods used in combinatorics. We will also discuss some topics from extremal combinatorics. Linear Algebraic methods: Basic techniques, polynomial space method, higher incidence matrices, applications to combinatorial and geometric problems. Probabilistic Methods: Basic techniques, entropy based method, martingales, random graphs. Extremal Combinatorics: Sun flowers, intersecting families, Chains and antichains, Ramsey theory.

Sunil Chandran L

References:

- L. Babai and P. Frankl: Linear algebra methods in combinatorics with applications to Geometry and Computer Science, Unpublished manuscript.
- N. Alon and J. Spenser: Probabilistic Method, Wiley Inter-science publication.
- Stasys Jukna: Extremal Combinatorics with applications in computer science, Springer.

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

Pre-requisites:

- Mathematical maturity.,Basic level crypto course.

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

Pre-requisites:
- A course on Machine Learning or equivalent

E0 337 (AUG) 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

Pre-requisites:
- A course in Cryptography and mathematical maturity.

E0 358 (AUG) 3:1

Advanced Techniques in Compilation and Programming for Parallel Architectures

Parallel architectures: a brief history, design, Auto-parallelization for multicores, GPUs, and distributed Memory clusters Lock-free and wait-free data structures/algorithms for parallel programming Study of existing languages and models for parallel and high performance programming; issues in design of new ones.

Uday Kumar Reddy B

References:
- Aho, Lam, Sethi, and Ullman, Compilers: Principles, Techniques, and Tools, 2nd edition
- Herlihy and Shavit, The Art of MultiProcessor Programming
- Ananth Grama, Introduction to Parallel Computing
- List of research papers and other material which will be the primary reference material will be available on course web page.

Pre-requisites:
- Knowledge of "E0 255 Compiler Design" course content (especially on parallelization) will be very useful, but not absolutely necessary.
- Knowledge of microprocessor architecture and some basic understanding of parallel programming models.

E0 399 (AUG) 1:2

Research in Computer Science

Contemporary topics of research in theoretical computer science, computer systems and software, intelligent systems. Motivation and objectives of the course : This course is meant for MTech (CSE) students. The idea behind the course is that a student works on a short research problem to get hands-on experience and also to develop soft skills necessary to conduct research. The 1 credit is for one contact hour per week between the instructor(s) and student(s) for discussion and presentations. The 2 credits is for the research work that the student conducts during the week on the course.

Srikant Y N, Shirish Krishnaji Shevade, Deepak DSouza

References:

- Recent literature

Pre-requisites:

- Prior consent of instructor(s)

E0 210 (JAN) 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.

Gopinath K

References:

- Course material available from the webpage; research papers

Pre-requisites:

- Basic knowledge of programming in C/C++/Java.

E0 228 (JAN) 3:1

Combinatorics

Basic combinatorial numbers, selection with repetition, pigeon hole principle, Inclusion-Exclusion Principle, Double counting; Recurrence Relations, Generating functions; Special combinatorial numbers: Sterling numbers of the first and second kind, Catalan numbers, Partition numbers; Introduction to Ramsey theory; Combinatorial designs, Latin squares; Introduction to Probabilistic methods, Introduction to Linear algebra methods.

Sunil Chandran L

References:

- R. P. Grimaldi, B. V. Ramana, "Discrete and Combinatorial Mathematics: An applied introduction", Pearson Education (2007)
- Richard A Brualdi, "Introductory Combinatorics", Pearson Education, Inc. (2004)
- Miklos Bona, "Introduction to Enumerative Combinatorics", Mc Graw Hill (2007)
- Miklos Bona, "A walk through Combinatorics: An introduction to enumeration and graph theory", World Scientific Publishing Co. Pvt. Ltd. (2006)
- J. H. Vanlint, R. M. Wilson, "A course in Combinatorics", Cambridge University Press (1992, 2001)
- Stasys Jukna, "Extremal Combinatorics: With applications in computer science", Springer-Verlag (2001)
- Noga Alon, Joel H. Spencer, P. Erdos, "The Probabilistic methods", Wiley Interscience Publication
- Laszlo Babai and Peter Frankl, "Linear Algebra Methods in Combinatorics, with Applications to Geometry and Computer Science" (Unpublished Manuscript, 1992)

Pre-requisites:

- None. (A very basic familiarity with probability theory and linear algebra is preferred, but not a must. The required concepts will be introduced quickly in the course.)

E0 238 (JAN) 3:1

Intelligent Agents

ntroduction 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

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.

Pre-requisites:

- E0225 : Design and Analysis of Algorithms

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

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, Arindam Khan

Pre-requisites:

- E0225: Design and Analysis of Algorithms.

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

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, Govindarajan R

E0 261 (JAN) 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.

Jayant R Haritsa

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.

Pre-requisites:

- Data Structures, C or C++, Undergraduate course in DBMS

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

Pre-requisites:

- NDSS(E0 254) or equivalent course

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, 2014 Hastie, Tibshirani and Friedman, The Elements of Statistical Learning, Springer, 2009 Recent literature

Shirish Krishnaji Shevade

Pre-requisites:
- Linear Algebra,Probability and Statistics,Some programming experience in any language.

E0 270 (JAN) 3:1

Machine Learning

Introduction to Machine Learning, classification using Bayes rule, introduction to Bayes decision theory. Learning as optimization, linear regression. Probabilistic view: ML and MAP estimates. Logistic Regression: Gradient Descent, Stochastic Gradient methods. Hyperplane based classifiers, Perceptron, and Perceptron Convergence Theorem. Support vector machine and kernel methods. Feedforward neural networks, backpropagation algorithm. Autoencoders, Convolutional neural networks, and application to computer vision. The sequence to sequence models, recurrent NN and LSTM and applications to NLP. Undirected Graphical Models, Markov Random Fields, Introduction to MCMC and Gibbs Sampling. Restricted Boltzmann Machine. EM algorithm, Mixture models and K-means, Bayesian Networks, Introduction to HMMs. Generative models: GANs and VAEs.

Chiranjib Bhattacharyya, Ambedkar Dukkipati

References:
- Bishop. C M, Pattern Recognition and Machine Learning, Springer, 2006.
- Hastie T, Tibshirani R and Friedman J, The Elements of Statistical Learning: Data Mining, Inference and Prediction, Springer, 2nd Edition, 2009
- Haykin. S, Neural Networks and Learning Systems, Prentice Hall, 3rd Edition, 2009
- Goodfellow, Bengio, Courville, Deep Learning, MIT Press, 2017

Pre-requisites:
- Probability and Statistics (or equivalent course elsewhere). Some background in linear algebra and optimization will be helpful.

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 and AFL.

Deepak DSouza, Raghavan K V

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.

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

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 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

Pre-requisites:

- 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, but not essential (background readings will be provided).

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

Pre-requisites:

- Mathematical maturity will be assumed.

E0 307 (JAN) 3:1

Program Synthesis meets Machine Learning

This course will have two parts: Part 1: In this part, we will cover the theory and fundamentals of program synthesis, including the recent formulations to restrict synthesis using templates, and reformulate synthesis as a search problem. We will also cover black-box formulations of synthesis, starting with the classic Angluin's algorithm [5] to its modern variants [6]. We will teach this part in a structured manner through planned lectures. Part 2: In this part, we will read and discuss recent papers exploring the combination of machine learning and program synthesis. Specific topics include: - Using ML to Rank Programs and Prune Search Space for Program Synthesis [7, 8] - Combining ML and synthesis [9] - Neural program induction [10, 11] - Automatic differentiation [12, 13] Motivation and objectives of the course: Program synthesis has its roots in formal methods and programming languages. The goal of program synthesis is to automatically generate a program (from a space of possible programs) which satisfies a specification written in logic. The problem has its roots in a paper by Church in 1957, and the initial breakthroughs were made by Buchi and Landweber (1969) and M O Rabin (1972) , who showed that the synthesis problem is decidable for specifications written in certain logics. However, the complexity of the algorithms was too high (Non-Elementary to EXPTIME) to be useful in practice. Recent formulations have made synthesis more practical . In his PhD thesis, Solar-Lezama formulated synthesis as "sketching" [2] , a process where part of the program is given by the user as a template and the synthesizer merely fills in "holes" in the sketch using search. Another recent formulation, due to Sumit Gulwani uses input/output examples (rather than formulas) as specifications [3] , and uses clever search algorithms to generate appropriate programs. Sparked by these two works, there has been a resurgence or work in program synthesis in the past decade. There is an annual Sygus competition [4] where practical tools compete every year. Recently there is an interesting interplay developing between program synthesis and machine learning. Machine learning uses continuous optimization methods to learn models that minimize a specified loss function, whereas program synthesis uses discrete combinatorial search to learn programs that satisfy a specification. While program synthesis produces interpretable programs, which can be formally verified, machine learning deals with noise in the inputs more gracefully. There is a rich body of recent work in combining machine learning and program synthesis to get the benefits of both approaches.

Chiranjib Bhattacharyya, Deepak DSouza

References:

- Alonzo Church, Application of recursive arithmetic to the problem of circuit synthesis, Summaries of talks presented at the Summer Institute for Symbolic Logic Cornell University, 1957.
- Solar-Lezama, Program Synthesis by Sketching, PhD Thesis, UC Berkeley, 2003
- Sumit Gulwani , Automating String Processing in Spreadsheets using Input-Output Examples. POPL 2011.
- Sygus competition, https://sygus. org.
- Angluin, D. Learning regular sets from queries and counterexamples. Inf. Comput. 75, 2 (1987) , 87–106.
- Vandrager, F. Model Learning, CACM, Feb 2017.
- Ashwin Kalyan, Abhishek Mohta, Alex Polozov, Dhruv Batra, Prateek Jain, Sumit Gulwani . Neural -Guided Deductive Search for Real –Time Program Synthesis from Examples, 6th International Conference on Learning Representations (ICLR) , January 2018.
- Sumit Gulwani , Prateek Jain, Programming by Examples: PL meets ML, Dependable Software Systems Engineering, Published by IOS Press, 2019.
- A Iyer, M Jonnalagedda, S. Parthasarathy, A. Radhakrishna, S. Rajamani , Synthesis and Machine Learning for Heterogeneous Extraction, to appear in PLDI 2019. [10] Abhinav Verma, Vijayaraghavan Murali , Rishabh Singh, Pushmeet Kohli , and Swarat Chaudhuri . 2018, Programmatically Interpretable Reinforcement Learning. In ICML 2018.
- Alex Graves, Greg Wayne, Ivo Danihelka, Neural Turing Machines, 2014.
- Scott Reed, Nando de Freitas, Neural Programmer Interpreters, 2016.
- Pearmutter & Siskind, Reverse mode AD in a functional framework, TOPLAS 2008.
- Elliott, The simple essence of automatic differentiation, ICFP 2018

Pre-requisites:

- We require students to have good knowledge in programming. We also require students to have taken an introductory course in Machine Learning (regression, classification, deep learning etc). We will not require prior exposure to program synthesis or formal methods. We will supply the necessary background in Part 1. Students will need to show initiative in reading papers for Part 2, and leading discussions in Part 2. Students will also need to do both theory and implementation for the project.

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

Pre-requisites:

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

E0 399 (JAN) 1:2

Research in Computer Science

Contemporary topics of research in theoretical computer science, computer systems and software, intelligent systems. Motivation and objectives of the course : This course is meant for MTech (CSE) students. The idea behind the course is that a student works on a short research problem to get hands-on experience and also to develop soft skills necessary to conduct research. The 1 credit is for one contact hour per week between the instructor(s) and student(s) for discussion and presentations. The 2 credits is for the research work that the student conducts during the week on the course.

Srikant Y N, Shirish Krishnaji Shevade, Deepak DSouza

References:
- Recent literature

Pre-requisites:
- Prior consent of instructor(s)

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 277 (JAN) 3:1

Reinforcement Learning

Introduction to reinforcement learning, introduction to stochastic dynamic programming, finite and infinite horizon models, the dynamic programming algorithm, infinite horizon discounted cost and average cost problems, numerical solution methodologies, full state representations, function approximation techniques, approximate dynamic programming, partially observable Markov decision processes, Q-learning, temporal difference learning, actor-critic algorithms. References: D.P.Bertsekas and J.N.Tsitsiklis, Neuro-Dynamic Programming, Athena Scientific, 1996. R.S.Sutton and A.G.Barto, Reinforcement Learning: An Introduction, MIT Press, 1998. D.P.Bertsekas, Dynamic Programming and Optimal Control, Vol.I, Athena Scientific, 2005.

Shalabh Bhatnagar

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

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.

Uday Kumar Reddy B, Vinod Ganapathy

Dept of Electrical Communication Engineering

M.Tech Communication & 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 Electives	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 203 (JAN) 3:0 Wireless Communication
E2 204 (JAN) 3:0 Stochastic Processes and Queueing Theory
E2 205 (AUG) 3:0 Error-Correcting Codes
E2 223 (AUG) 3:0 Communication Protocols
E2 241 (JAN) 3:0 Wireless Networks
E2 242 (JAN) 3:0 CDMA & Multiuser Detection
E8 203 (AUG) 3:0 RF & Optical Engineering

Pool B (in no particular order)
E0 251 (AUG) 3:1 Data Structures & Algorithms
E0 259 (AUG) 3:1 Data Analytics
E1 251 (AUG) 3:0 Linear and Nonlinear Optimization
E1 254 (AUG/JAN) 3:1 Game Theory
E2 212 (AUG) 3:0 Matrix Theory
E9 201 (AUG) 3:0 Digital Signal Processing
E9 211 (JAN) 3:0 Adaptive Signal Processing

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) 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) 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 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
E9 262 (JAN) 3:0 Stochastic Models for Speech/Audio

M-Tech Microelectronics and VLSI Design Program's course / curriculum

Course and Project Credit: The core and soft-core courses are listed in the table below. Most of the courses have a serious lab component. The credit distribution is summarized as follows:

A. **Core courses (18 credits):** There are 6 courses (mix of 1:2, 2:1 and 3:0 credits) that are mandatory for M. Tech students.

B. **Soft Core (9 credits):** There are total 9 soft core courses, which directly fall under the scheme of Microelectronics and VLSI Design. Students must credit minimum 3 courses from this pool.

C. **Electives (9 credits):** The remaining 9 credits of coursework may be completed by crediting courses listed in the Scheme of Instructions. It's worth highlighting that our faculties offer over 10 different relevant courses, other than what is listed below, from which students can fulfil the elective requirements. Students can also credit soft cores (beyond 9 credits) to fulfil elective requirement.

D. **Project (28 credits):** This is a 1-year project (2 semesters including the summer terms).

#	Course No.	Course title	Nature	Term
1	E3 282	Basics of Semiconductor Devices and Technology	Core	August
2	E3 220	Foundations of Nanoelectronics Devices	Core	August
3	E3 200	Microelectronics Lab	Core	August
4	E0 284	Digital VLSI Circuit	Core	August
5	E3 238	Analog VLSI Circuits	Core	August
6	E3 231	Digital Systems Design with FPGAs	Core	Jan
7	E3 275	Physics and Design of Transistors	Soft Core	Jan
8	E3 280	Carrier Transport in Nanoelectronics Devices	Soft Core	Jan
9	E3 225	Art of Compact Modelling	Soft Core	August
10	E7 214	Optoelectronic Devices	Soft Core	Jan
11	E3 237	Integrated Circuits for Wireless Communication	Soft Core	Jan
12	E3 245	Processor System Design	Soft Core	August
13	E8 242	RF IC and Systems	Soft Core	Jan
14	E8 202	Computational Electromagnetics	Soft Core	August
15	E7 211	Photonic Integrated Circuits	Soft Core	Jan
16	E3 274	Design of Power Semiconductor Devices	Soft Core	Jan
17	E3 271	Reliability of Nanoscale Circuits and Systems	Soft Core	Jan

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

References:

- 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

Pre-requisites:

- A basic course on probability or random processes

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.

Rajesh Sundaresan

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.

Pre-requisites:

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

E2 201 (AUG) 3:0

Information Theory

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

Himanshu Tyagi

References:

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

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

References:

- 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
- Introduction to Probability, Dimitri P. Bertsekas and John N. Tsitsiklis, 2nd edition, 2008.

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.

Vijay Kumar P

References:

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

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

References:

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

E2 212 (AUG) 3:0

Matrix Theory

Vectors, vector norms, vector algebra, subspaces, basis vectors, Gramm-Schmidt orthonormalization. Matrices, matrix rank, matrix norms, determinant, inverse, condition number. Hermitian and symmetric matrices, positive definite matrices, unitary matrices, projection matrices and other special matrices. LDU decomposition, QR decomposition, eigenvalue decomposition, singular value decomposition. Solving linear system of equations using Matrices. Least-squares approach, total least squares approach. Numerical issues. Perturbation theory of matrices. Differentiation of scalar functions of vectors and matrices. Matrix functions of scalar variables, Kronecker product of matrices. Positive matrices, nonnegative matrices, stochastic matrices and Markov chains.

Ramakrishnan A G

References:

- References: Carl D Meyer, Matrix Analysis and Applied Linear Algebra, SIAM Publication, 2000 Theodore Shifrin and Malcolm Ritchie Adams, Linear Algebra: A Geometric Approach, W H Freeman and Comapany, Second Edition, 2011,Gilbert Strang, Linear Algebra and its Applications, Fourth Edition, Thomson Brooks/Cole, 2007. Horn, and Johnson, Matrix Analysis, Second Edition, Cambridge University press, 2017,Golub, and Van Loan, Matrix Computations, Fourth Edition, John Hopkins University Press, 2015

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

References:

- R.G. Gallager, Information Theory and Reliable Communication, Wiley, 1968
- Relevant journal papers

Pre-requisites:

- E2 201 (Information theory)

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

References:

- 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 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

References:

- 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

E2 302 (AUG) 3:0

Next Generation Wireless Systems: Design and Analysis

Theory, design techniques, and analytical tools for characterizing next generation wireless systems. Performance analysis of digital communication systems over fading channels, rate and power adaptation, and multi-user diversity techniques; Study of LTE standard, its air interface, physical and logical channels, and physical layer procedures. Survey of advanced technologies such as cooperative communications and cognitive radio.

Neelesh B Mehta

Pre-requisites:

- E2 211 “Digital Communications”

E2 331 (AUG) 3:0

Advanced Topics in Coding Theory

Topics will be drawn from the following: Coding for distributed computing and storage, Straggler mitigation, Coded caching, Multi sender index coding, and Private information retrival.

Sundar Rajan B

Pre-requisites:

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

E2 336 (AUG) 3:0

Foundations of Machine Learning

- Support Vector Machines, Kernel methods - PAC learning framework, learning via uniform convergence - Bias complexity trade-off, Rademacher complexity, VC-dimension - Linear predictors, regression, boosting, model selection, convex learning, regularization, algorithmic stability - Online learning, clustering, dimensionality reduction, reinforcement learning - Multi-class classification, ranking, decision trees, nearest neighbors, neural networks

Vinod Sharma, Parimal Parag

References:

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

Pre-requisites:

- Random processes

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

References:

- 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

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

References:

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

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

References:

- A. Selvarajan, S. Kar and T. Srinivas, Optical Fiber Communications, Principles and Systems, Tata – McGraw 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 course The course will have programming assignments (using Matlab/Fortran/C++).

Vinoy K J, Dipanjan Gope

References:

- A. Taflove and SC Hagness Computational Electrodynamics: The Finite Difference Time Domain Method, 3rd 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.

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

References:

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

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.

Sundeep Prabhakar Chepuri

References:

- Ali H Sayed, Adaptive Filters, John Wiley/IEEE, 2008

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.

Sundeep Prabhakar Chepuri

References:

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

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

References:

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

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.

Parimal Parag

References:

- 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.

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

References:

- 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.

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

References:

- 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

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

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

Pre-requisites:
- E2 205 (Error-Correcting Codes)

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

References:
- Behzad Razavi, RF Microelectronics
- Thomas Lee, The Design of CMOS RF Integrated Circuits

Pre-requisites:
- Analog VLSI Circuits E3 238

E7 211 (JAN) 2:1

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

References:
- 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 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 (responsivity, 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

References:

- 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. Bhattacharya, "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

References:

- 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.

E8 262 (JAN) 3:0

CAD for High Speed Chip-Package-Systems

Dipanjan Gope

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.

Chandra R Murthy

References:

- M. Elad, “Sparse and Redundant Representations”, Springer, 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 Connexions Course, 2011.

Pre-requisites:

- Random Processes, Matrix Theory.

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.

Hari K V S

References:

- 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.

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

References:

- A. Paulraj, R. Nabar and D. Gore. Cambridge University Press, 2003.
- Current literature

Pre-requisites:

- Digital Communication, Introduction to Space-Time Wireless Communications,

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.

Navin Kashyap

Department of Electrical Engineering

The department of Electrical Engineering at Indian Institute of Science offers a vibrant environment for postgraduate education and research in Electrical Engineering. Established in 1911, it is one of the first few departments at IISc. The vision of the department is to provide the leadership to enable India's excellence in the field of Electrical Engineering. The department is committed to advancement of the frontiers of knowledge in Electrical Engineering and to provide the students with a stimulating and rewarding learning experience.

The department is currently engaged in research in many areas of Electrical Engineering including Power Systems, Energy Studies, Power Electronics, Electrical Drives, High Voltage engineering, Signal Processing, Image Processing and Multimedia, Biomedical Imaging, Machine Learning, Pattern Recognition, etc.

The department admits students for 2-year M Tech programs as well as research programs leading to Ph.D. and M Tech(Res) degrees.

The department is recognized as a Center for Advanced Studies in Electrical Engineering by University Grants Commission.

The department of Electrical Engineering offers three masters programs based on course work.

- M Tech - Electrical Engineering
- M Tech - Artificial Intelligence, offered by Division of Electrical, Electronics and Computer Science
- M Tech - Signal Processing offered jointly with department of Electrical Communications Engineering

Students with a bachelor’s degree in relevant engineering disciplines are eligible for admission. The admission is based on the GATE score, Written test and Interview for MTech (EE) and MTech (AI) Programmes and GATE score and Interview for MTech (SP) Programme. Details regarding specific eligibility criteria for the different MTech degrees and procedure for application etc. are available in the Admission Brochure.

For more details, please visit http://www.ee.iisc.ac.in

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

References:
- Raghavendra C S,Shivalingam K M and Znati T,Wireless Sensor Networks,Springer

Pre-requisites:
- Consent of Instructor

E0 299 (AUG) 3:1

Computational Linear Algebra

Theory: Solution of linear equations, vector space, linear transformation, matrix representation, inner-products and norms, orthogonality, least squares, trace and determinant, eigendecomposition, symmetric (Hermitian) matrices and quadratic forms, singular value decomposition, and applications. Computations: Gaussian elimination, iterative methods, QR decomposition, eigenvalues, power method, QR algorithm.

Kunal Narayan Chaudhury

References:
- S. Axler, Linear Algebra Done Right, Springer, 2015.
- G. Strang, Introduction to Linear Algebra, Wellesley-Cambridge Press, 2016.
- L. Trefethen and D. Bau, Numerical Linear Algebra, SIAM, 1997.

Pre-requisites:
- none.

Co-requisites:
- none.

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:
- 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 dynamical 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

References:

- Joao P. Hespanha, “Linear systems theory”, Princeton University Press, 2009; Panos J. Antsaklis, Anthony N. Mitchel, "Linear Systems", Birkhauser, 1997; Chi-Tsong Chen, “Linear System Theory and Design”, Oxford University Press; Thomas Kailath, “Linear Systems”, Pearson, 2016 reprint of 1980 edition; Gilbert Strang, “Linear algebra and its applications”

Co-requisites:

- (Linear algebra or equivalent) OR (Permission of the instructor) AND (Basic knowledge of linear ODEs)

E1 251 (AUG) 3:0

Linear and Nonlinear Optimization

Necessary and sufficient conditions for optima; convex analysis; unconstrained optimization; descent methods; steepest descent, Newton’s method, quasi Newton methods, conjugate direction methods; constrained optimization; Kuhn-Tucker conditions, quadratic programming problems; algorithms for constrained optimization; gradient projection method, penalty and barrier function methods, linear programming, simplex methods; duality in optimization, duals of linear and quadratic programming problems

Muthuvel Arigovindan

References:

- References: Luenberger D G,Introduction to Linear and Nonlinear Programming,2nd edition,Addison Wesley,1984.

E4 221 (AUG) 2:1

DSP and AI Techniques in Power System Protection

Introduction to digital relaying, signal conditioning, sampling and analog to digital conversion, real time considerations, hardware design concepts – microcontroller/DSP based, single/multiprocessor based. Relaying algorithms, software considerations. Digital protection schemes for feeders, transmission lines, generators and transformers, integrated protection scheme – a case study, New relaying principles based on AI techniques, ANN approach and Fuzzy Logic (FL) methods for fault detection and fault location. Software tools for digital simulation of relaying signals, playback simulators for testing of protective relays Laboratory Exercises – Digital techniques for the measurement of phasors, frequency and harmonics, implementation of relaying algorithms and digital protection schemes on hardware platforms. Testing of relays, transient tests based on EMTP data. Design procedures of AI based relays using software tools. Mini-projects.

Jayachandra Shenoy U

References:

- References: Warrington A R, and Von C, Protective Relaying: Theory and Practice, Vol. II, Chapman and Hall, 1970.,IEEE Tutorial Course on Microprocessor Relays and Protection Systems, Power Systems Research Group, University of Saskatchewan, 1979 and 1987.,Phadke A G, and Thorp J, Computer Relaying for Power Systems, John Wiley, Inc. 1988.,IEEE Tutorial Course on Advancement in Microprocessor Based Protection and communication, 1997.,Technical papers from IEEE transactions, CIGRE, IEE journals.

E4 231 (AUG) 3:0

Power System Dynamics and Control

Introduction to system dynamics, concepts of stability, modeling of generator, transmission networks, loads and control equipment, small signal stability-low frequency oscillations – methods of analysis for single and multi-machine systems, power system stabilizers.

Gurunath Gurrala

References:

- References: Padiyar K R,Power System Dynamics,Stability and Control,Interline Publishing,1996.

E4 234 (AUG) 3:0

Advanced Power Systems Analysis

Introduction to Power System Analysis; Admittance Model of Power System Elements; Kron's Reduction; Power Flow Analysis: Gauss–Seidel, Newton Raphson, Fast Decoupled; Programming Consideration for Large Systems; Balanced and Unbalanced Radial Power Flow, AC-DC Power Flow, Harmonic Power Flow, Continuation Power Flow; Steady-State Voltage Stability; Power Flow Tracing; Loss Allocation Methods; Network Congestions; Available Transfer Capability; Contingency Analysis; Z-Bus Formulations; Fault Analysis using Z-Bus; Structure of Indian Power Systems; Indian Electricity Grid Code.

Sarasij Das

References:

- References: Kusic G L, Computer Aided Power System Analysis, CRC Press, 2nd edition, 2009.,Arilaga J, and Watson N R, Computer Modelling of Electrical Power Systems, Wiley, 2005.,Grainger J J, and Stevenson W D, Power System Analysis, McGraw Hill Education (India) Pvt Ltd., 2003.,Wang X, Song Y and Irving M, Modern Power Systems Analysis, Springer, 2008,Arilaga J, and Watson N R, Power System Harmonics, Wiley, Second Edition, 2003.

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.

Subba Reddy Basappa, Rajanikanth B S

References:

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

E5 213 (AUG) 3:0

EHV/UHV Power Transmission Engineering

E4 213 (Aug) 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 audio-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:

- Extra High Voltage AC Transmission Engineering – R.D. Begamudre, Wiley Eastern Limited, 1990
- Transmission line Reference Book 345 kV & above, Electrical Power Research Institute, (EPRI), 1982 USA.

E5 215 (AUG) 2:1

Pulsed Power Engineering_*

Overview of Pulsed Power Engineering, pulsed power generators, PFN schemes, Marx circuits, Magnetic pulse compression, power conditioning systems, measurement techniques or pulsed power parameters,insulation requirements for pulsed power systems, specific insulation systems used in pulsed power systems - gaseous, liquid, solid and magnetic insulation and their behaviour under pulsed voltages, Applications of pulsed power systems, pulsed power systems for high power lasers, Lightning, NEMP and ESD simulators, HPM, IRA, coilgun and railgun applications, pulsed power systems for biological and pollution control applications.

Joy Thomas M

References:

- Advances in Pulsed Power Technology, Vol. 1 & 2, Plenum Press, New York, 187, 1990.
- Current literature from journals and conference proceedings

E5 253 (AUG) 2:1

Dielectrics and Electrical Insulation Engineering_*

Joy Thomas M

E6 201 (AUG) 3:1

Power Electronics

Power switching devices: diode, BJT. MOSFET, IGBT; internal structure, modeling parameters, forward characteristics and switching characteristics of power devices; control and protection of power switching devices; electromagnetic elements and their design; choppers for dc to dc power conversion; single and multi-quadrant operation of choppers; chopper controlled dc drives; closed loop control of dc drives. Hands-on exercises: soldering and desoldering practice, pulse generator circuit, inductor design and fabrication, thermal resistance of heat sink, switching characteristics of MOSFET, dc-dc buck converter, CCM and DCM operation, linear power supply, output voltage feedback for over-current protection, dc-dc boost converter, measurement of small-signal transfer functions, closed loop control of boost converter.

Narayanan G

References:

- References: Mohan N, Power Electronics; Principles, Analysis and Design , John Wiley, 1989.,Robert Ericson, Fundamentals of Power Electronics, Chapman & Hall, 1997,Umanand L, Power Electronics: Essentials and Applications, Wiley India, 2009,Baliga B J, Power Semiconductor Devices,. PWS Publishing Company, 1996,Sorab K.Ghandhi, Semiconductor Power Devices, John Wiley and Sons, 1976

E6 224 (AUG) 3:0

Topics in Power Electronics and Distributed Generation

Introduction to distribution systems, fault calculations, fault contribution and protection coordination with DG, distribution systems grounding, impact of DG on grounding, intentional and unintentional islanding, dynamic phasor modelling and detection methods, relaying requirements for DG systems. Online tap changes, series voltage regulators, feeder voltage control and voltage profile, ring feeders and network distribution. Economic considerations for DG systems, cost of energy and net present cost calculations. Power converters for grid interconnection for single phase and three phase systems. Voltage source inverter design issues, DC bus capacitor design selection, reliability and lifetime, power semiconductor component selection and design for efficiency and reliability, filtering requirements. Noise considerations in power electronic systems, coupling mechanism, common mode and differential mode analysis of power electronics circuits and circuit symmetry, self and external shielding, filtering and referencing of circuits. Control requirements for DG.

Vinod John

References:

- V. Ramanarayanan, Switched Mode Power Conversion, 2010.
- Arthur R, Bergen, Vittal, Power Systems Analysis (2nd Ed) Prentice Hall, 1999.
- Ned Mohan, Tore M, Undelnad, William P, Robbins (3 Edition), Power Electronics: Converters, Applications and Design; Wiley 2002.
- IEEE papers and standards, datasheets, current literature.

Pre-requisites:

- None (Students are expected to be familiar with power electronics)

E6 225 (AUG) 3:0

Advanced Power Electronics

Rectifiers: Line commutated, unidirectional power factor correction (PFC), bi-directional, rectifiers with isolation. AC to AC power converters: Matrix converters, Multistage conversion: voltage link and current link topology, High frequency link converters. DC to DC converters: Dual active bridge, Resonant converters. Inverters: Multilevel, Inverters for open ended load configurations, Resonant inverters. High frequency magnetics: Modeling and loss estimation, Inductor and transformer design. Thermal design. Emerging power semi-conductor devices.

Kaushik Basu

References:

- Ned Mohan, Tore M Undeland, William P Robbins, Power Electronics: Converters, Applications and Design, Wiley, Third Edition 2007.,Erickson R W and Maksimovic D, Fundamentals of Power Electronics, Springer, Second Edition 2005.,Umanand L, Power Electronics and Essentials, Wiley, 2009.,Ramanarayanan V, Switched Mode Power Conversion, Course Notes, IISc, 2004. Current literature

Pre-requisites:

- E6 201:Power Electronics or E6 202: Design of Power Converters

E8 201 (AUG) 3:0

Electromagnetism

Review of basic electrostatics, dielectrics and boundary conditions, systems of charges and conductors, Green's reciprocation theorem, elastance and capacitance co-efficient, energy and forces, electric field due to steady currents, introduction to magnetostatics, vector potential, phenomena of induction, self and mutual inductance, time-varying fields, Maxwell's equations.

Udaya Kumar

References:

- References:,Kraus J D, Electromagnetics, McGraw Hill International.,Jeans J H, The Mathematical Theory of Electricity and Magnetism, Cambridge University Press.,Smythe W R, Static and Dynamic Electricity, McGraw Hill Book Company, New York.

E9 201 (AUG) 3:0

Digital Signal Processing

Discrete-time signals and systems, frequency response, group delay, z-transform, convolution, discrete Fourier transform (DFT), fast Fourier transform (FFT) algorithms, discrete Cosine transform (DCT), discrete Sine transform (DST), relationship between DFT, DCT, and DST; design of FIR and IIR filters, finite word length effects, Hilbert transform, Hilbert transform relations for causal signals, Karhunen-Loève transform. Introduction to linear prediction, bandpass sampling theorem, bandpass signal representation.

Soma Biswas, Prasanta Kumar Ghosh

References:

- References:,Proakis and Manolakis, Digital Signal Processing, Prentice Hall India,.,Oppenheim A V , Schafer R W, Discrete-time Signal Processing, Prentice Hall, 1998.,Sanjit K Mitra, Digital Signal processing : A Computer Based Approach, Tata McGraw-Hill

E9 205 (AUG) 3:1

Machine Learning for Signal Processing

Introduction to real world signals - text, speech, image, video. Feature extraction and front-end signal processing - information rich representations, robustness to noise and artifacts. Basics of pattern recognition, Generative modeling - Gaussian and mixture Gaussian models, factor analysis. Discriminative modeling - support vector machines, neural networks and back propagation. Introduction to deep learning - convolutional and recurrent networks, attention models, pre-training and practical considerations in deep learning, understanding deep networks. Deep generative models - Autoencoders, Boltzmann machines, Adversarial Networks, Variational Learning. Applications in NLP, computer vision and speech recognition.

Sriram Ganapathy

References:

- "Pattern Recognition and Machine Learning", C.M. Bishop, 2nd Edition, Springer, 2011.
- "Neural Networks", C.M. Bishop, Oxford Press, 1995.
- "Deep Learning", I. Goodfellow, Y, Bengio, A. Courville, MIT Press, 2016.

Pre-requisites:

- Random Process / Probablity and Statistics
- Linear Algebra / Matrix Theory

E9 241 (AUG) 2:1

Digital Image Processing

Continuous image characterization, sampling and quantization, 2D Fourier transform and properties, continuous/discrete image processing, rotation, interpolation, image filtering (shift-invariant filters, bilateral filters, nonlocal means), spatial operators, morphological operators, edge detection, texture, 2-D transforms (discrete Fourier transform, discrete cosine transform, Karhunen-Loève transform, wavelet transform), image pyramid, image denoising, segmentation, restoration.

Chandra Sekhar Seelamantula, Rajiv Soundararajan

References:

- References: Lim J S,Two-dimensional signal and image processing,Prentice Hall,1990.,Jain A K, Fundamentals of digital image processing, Prentice Hall, 1989. Gonzalez R. C. and Woods R. E., Digital image processing, Prentice Hall, 2008. Dudgeon D.E. and Merserau R. M., Multidimensional digital signal processing, Prentice Hall Signal Processing Series, 1983.

E9 245 (AUG) 3:1

Selected Topics in Computer Vision

This course will develop the use of multiview geometry in computer vision. A theoretical basis and estimation principles for multiview geometry, dense stereo estimation and three-dimensional shape registration will be developed.The use of these ideas for building real-world solutions will be emphasised. Topics Stereo estimation: current methods in depth estimation 3D registration: ICP and other approaches Multiple view geometry: projective geometry. Multilinear relationships in images, estimation.

Srinivasa Venu Madhav Govindu

References:

- Hartley R, and Zisserman A, Multiple View Geometry in Computer Vision, Second Edn, Cambridge University Press, 2004.,Faugeras O, and Luong Q T,The Geometry of Multiple Images, MIT Press 2001.,Current literature

Pre-requisites:

- E1 216 or permission of the instructor.

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:

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

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:

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

E0 265 (JAN) 3:1

Convex Optimization and Applications

Introduction. Convex sets and functions. Basic convex programs. Optimality, duality, KKT conditions. Algorithms: gradient descent (GD), projected GD, stochastic GD, proximal gradient, ADMM.

Kunal Narayan Chaudhury

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:

- 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

E1 242 (JAN) 3:0

Nonlinear systems and control

Equilibria and qualitative behavior, Existence and uniqueness of solutions, Lyapunov stability, invariance principle, converse theorems, ultimate boundedness, input-to-state stability, Input-output stability, small-gain theorem, passivity. Selected topics, examples and applications from: Feedback linearization, gain scheduling, sliding mode control, backstepping; Switched and hybrid systems; Applications in networked control systems and distributed control.

Pavankumar Tallapragada

References:

- H. K. Khalil. Nonlinear Systems. Prentice Hall, 3 edition, 2002.
- S. S. Sastry. Nonlinear Systems: Analysis, Stability and Control. Number 10 in Interdisciplinary Applied Mathematics. Springer, 1999.
- Mathukumalli Vidyasagar. Nonlinear systems analysis. Society for Industrial and Applied Mathematics, 2002.
- E. D. Sontag. Mathematical Control Theory: Deterministic Finite Dimensional Systems, volume 6 of TAM. Springer, 2 edition, 1998

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.

Kaushik Basu

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.

Pre-requisites:

- 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.

E4 233 (JAN) 3:0

Computer Control of Power Systems

Gurunath Gurrala

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:

- 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

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:

- 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

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:

- 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 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:

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

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:

- 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 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:

- 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.

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, quasi resonant converters and resonant transition converters. Laboratory exercises on : Opamp circuits for current and voltage sensing in converters, differential 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, dynamic response and compensator design for dc-dc converters.

Vinod John

References:

- 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.

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:

- 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.

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:

- 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 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

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.

Pre-requisites:

- E9 241: Digital Image Processing

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

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.

Pre-requisites:

- E9-201 or consent of the instructor.

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:

- 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 285 (JAN) 3:0

Biomedical imaging - Inverse problems

STATISTICAL PRINCIPLES: image reconstruction as MAP estimation, and penalized maximum likelihood estimation; regularization as cross-entropy. IMAGING FORWARD MODEL FOR ITERATIVE RECONSTRUCTION: forward model for fluorescence microscopy; forward models for MRI; forward models for photo-acoustic tomography. REGULARIZATION: wavelet regularization, total variation regularization, Hessian-Schatten norm regularization, total generalization variation regularization. OPTIMIZATION METHODS: Majorization-Minimization, primal dual method, alternating direction method of multipliers (ADMM). DETERMINATION OF REGULARIZATION PARAMETER: method of generalized cross validation, risk minimization methods tuned for Gaussian, Poisson and Poisson-Gaussian noise model.

Muthuvel Arigovindan

Pre-requisites:
- Selected paper from recent literature
- Should have taken a linear algebra course
- Basic calculus will be needed

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

E9 306 (JAN) 1:2

Machine Learning in Neuroscience

Signal, image processing and machine learning applications to recent trends in neuroscience research, such as auditory neuroscience; brain computer interface; biofeedback; sleep research; neural mechanisms and rehabilitation in coma; analysis of infradian, circadian and ultradian rhythms; interrelationships between biological signals; connectome and functional connectivity analysis.

Ramakrishnan A G

References:

- (1) Rao, Rajesh PN. Brain-computer interfacing: an introduction. Cambridge University Press, 2013. (2) Sebastian Seung. Connectome: How the brain's wiring makes us who we are. HMH, 2013. (3) Gazzaniga, M.S. The cognitive neurosciences. MIT press, 2009. (4) Dunlap, J.C., Loros, J.J. and DeCoursey, P.J. Chronobiology: biological timekeeping. Sinauer Associates, 2004. (5) Berry, Richard B., et al. "The AASM manual for the scoring of sleep and associated events." Rules, Terminology and Technical Specifications, Darien, Illinois, American Academy of Sleep Medicine, 2012. (6) Broadbent, Donald Eric. Perception and communication. Elsevier, 2013. (7) Recent Literature.

Pre-requisites:
- One or more of: NS201: Fundamentals of Systems and Cognitive Neuroscience;
- E9 282: Neural Signal Processing; E9 201 :Digital Signal Processing
- E9 241 :Digital Image Processing; E9 205: Machine Learning for Signal Processing
- E1 213: Pattern Recognition and Neural Networks; E0 270: Machine Learning

EP 299 (JAN) 0:24

Dissertation Project (SE)

Dissertation Project (SP)

Satish L, Vijay Natarajan

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, Vijay Natarajan

E6 226 (MAY) 3:0

Switched Reluctance Machines and Drives

Review of magnetic circuits, energy stored in a magnetic circuit, magnetic circuits with a moving / rotating element in the air gap, force / torque as a partial derivative of stored energy with respect to linear / angular position of the moving / rotating element, effect of magnetic saturation. Constructional features of switched reluctance machines, doubly salient structure, examples of 6/4 and 8/6 machines, basic operating principle, study of motor behaviour from stator terminals, current response to fixed stator voltage with rotor blocked, static flux-linkage characteristics, static torque characteristics, inductance profile at low currents, total and incremental inductances, motoring and generating based on inductance profile, motoring and generating based on flux-linkage characteristics, back-emf response to constant current injection at constant rotor speed, back-emf characteristics. DC-DC converters, asymmetric and symmetric H-bridge converters; current control of DC-DC converters with passive and active loads; current control of DC-AC converters with passive loads, loads with sinusoidal back emf, and loads with non-sinusoidal back emf. Current control of switched reluctance machine, square wave current reference for motoring and generating, current tracking, hysteresis control or delta modulation, PWM control, PI based current control, linearization of nonlinear plant for controller design, equilibrium points for linearization, frequency responses of linearized models, selection of controller parameters, back-emf estimation, back-emf compensation. Phase current, phase torque and total torque; average torque, torque pulsations, current reference waveshapes to reduce torque pulsation; structure for torque control and speed control; torque reference and torque controller design; speed controller design. Reference: T.J.E Miller, “Switched reluctance motors and their control”, Magna Physics Publishing, Oxford Science Publications, 1993 T.J.E. Miller, “Electronic control of switched reluctance machines,” Newnes Power Engineering Series, 2001 K. Venkataratnam, “Special electric machines,” Orient Black Swan, 2008 Krishnan Ramu, “Switched reluctance motor drives: modeling, simulation, analysis, design and application,” CRC Press, 2001 Recent research publications

Narayanan G

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 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	Art of Compact Modeling
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	1:2	Jan	Reliability of Nanoscale Circuits and Systems
E3 272	3:0	Jan	Advanced ESD Devices, Circuits and Design Methods
E3 274	1:2	Jan	Design of Power Semiconductor Devices

E3 275	3:0	Jan	Physics and Design of Transistors
E3 276	2:1	Jan	Process Technology and System Engineering for Advanced Microsensors and Devices
E6 212	3:0	Jan	Design and Control of Power Converters and Drives
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
E9 253	3:1	Jan	Neural Networks and Learning Systems
Project: 25 Credits			
EP 299	0:25		Dissertation Project

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

References:

- 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

E2 230 (AUG) 3:0

Network Science and Modeling

Introduction to main mathematical models used to describe large networks and dynamical processes that evolve on networks. Static models of random graphs, preferential attachment, and other graph evolution models, Epidemic propagation, opinion dynamics, and social learning, Applications drawn from physical, informational, biological, cognitive, and social systems as well as networked decision systems such as Internet

Chandramani Kishore Singh

References:

- M. Newman. Networks: An Introduction. Oxford University Press, 2010
- D. Easley and J. Kleinberg, Networks, Crowds and Markets
- Current Literature

Pre-requisites:

- Random Processes or Stochastic Models and Applications or any equivalent course

Co-requisites:

- none

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

References:

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

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

References:

- 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 200 (AUG) 1:2

Microelectronics Lab

1. Device TCAD and Device Design Basics using TCAD: Device TCAD Models, Device Simulation Approach, Design of CMOS (nMOS/pMOS) devices using TCAD device simulations, Design of FinFET using device simulations, Analysis of Physical Parameters and Device Physics using TCAD, Parameter extraction from simulation results 2. CMOS Process Technology, Process Development, Integration and Simulation: Processing Steps - Lithography, Etching, Dopant Implantation, Material Deposition, Thermal annealing / Dopant Diffusion and Backend Metallization. TCAD Process simulation - Unit process simulation, process calibration, process integration, simulation of basic CMOS devices. TCAD simulation of standard cell library element, Advance CMOS device design, process simulation and process integration, Basics of 3D process simulation, Layout design for test chips development, Details of Mask writing and device fabrication 3. Semiconductor Device Characterization: Non-destructive and destructive characterization. Discussions on electrical, optical, and material characterization. Hands-on on Measurement systems - Probe stations, source-measurement units, function generators, cables and adapters, pulse generators, VNA, Oscilloscopes, power supplies. Hands-on: Characterization of range of FETs and Diodes. Various types of measurements (Extraction of terminal characteristics, Two-probe and four-probe measurements, Hall measurements, Low-voltage and low-current measurements, High-voltage and high-current measurements, Noise measurements, High-frequency/RF measurements, AC, DC, pulse, CV, transient measurements, Low-temperature, low-pressure measurements, Electro-optical measurements – on-the-fly Raman, EL/PL.) Extraction of Various Parameters (Threshold voltage, transconductance, contact resistance, Schottky barrier height, subthreshold slope, ON resistance, ON current, Junction temperature, doping profile, trap density, capacitance profile) 4. Library / PDK Development: Model Card Extraction (using TCAD data) using ICCAP, Standard Cell Library Design (Cell View), Standard Cell Library Characterization and Library simulation using ADS

Mayank Shrivastava

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.

Umanand L

References:

- 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 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

References:

- 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

Pre-requisites:

- E0 284 Digital VLSI Circuits
- E3 231 Digital System Design with FPGAs

E3 260 (AUG) 2:1

Embedded System Design – II

Review of an embedded system without OS, Software components: startup code, boot loader, kernel, applications. Realtime concepts for embedded systems, Basic OS constructs Semaphores, Mutex, Queues, Tasks, and Scheduler, Introduction to a real-time kernel, scheduling policies, mutual exclusion, and synchronization, inter-task control flow, inter-task data flow, memory management, interrupt processing. Linux for embedded applications: an overview of Linux kernel architecture; system call interface. Process management; memory management; file system architecture. Linux for micro-controllers and real-time applications. Device driver: character, block and network drivers. Designing a real-time system: development life cycle, modeling a real-time system, Case studies.

Dagale Haresh Ramji

References:

- Real TIme Concepts for Embedded Systems by Qing Li and Caroline Yao, ELSEVIER
- Embedded Systems - Real-Time Operating Systems by Jonathan W. Valvano
- Understanding Linux Kernel by Bovet, D., and Cesati, M. O'Reilly Publication

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

References:

- 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

References:

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

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

References:

- P. Bremaud, Markov Chains: Gibbs Fields, Monte Carlo Simulation, and Queues, Springer, 2001
- M. Jordan (ed.), Learning in Graphical Models, MIT Press, 1998
- M. Mézard and A. Montanari, Information, Physics and Computation, Oxford University Press, 2009

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

References:

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

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, Xilinx 7 Series FPGA architecture, programming FPGA, constraints, STA, timing closure, case study.

Kuruvilla Varghese

References:

- 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

References:

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

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

References:

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

E3 271 (JAN) 1:2

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

References:

- 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 274 (JAN) 1:2

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

References:

- 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 276 (JAN) 2:1

Process Technology and System Engineering for Advanced Microsensors and Devices

Introduction and Overview of Microfabrication Process Technology: Classification of Cleanrooms, Standard Operating Procedures for Working in a Conventional Clean Room Environment: Gowning Procedure, Operating Conditions, Clean Room Protocols, Safety and Contamination Issues in a Cleanroom, Overview of Cleanroom Hazards, Overview of Processes used in the Fabrication of Microsensors and Devices; Silicon Wafers - From Sand to the Laboratory: Silicon Growth Techniques: Czochralski and Float Zone, Wafer Processing from Si Ingot, Wafer Types: Crystallographic Planes, Physics of Silicon as a Semiconductor, Crystal Defects, Silicon Wafer Cleaning Methods: Piranha, RCA-1, RCA-2 using Wet-Benches; Thin Film Growth and Deposition Techniques: Thermal Oxidation, The Deal-Grove Model of Oxidation, Rate coefficients, Wet and Dry Oxidation, Overview of Oxidation Furnaces, Oxide Defects and ways of Mitigating it During Process Run, Contamination Control in the Furnace, Vacuum Systems: Construction and Working, Fundamentals of Material Deposition Techniques: Overview of Physical Vapor Deposition (Sputtering, Thermal and E-beam evaporation) and Chemical Vapor Deposition (LPCVD, PECVD, MOCVD, ALD); Doping - Diffusion and Ion implantation techniques: Diffusion process, Fick's Diffusion Laws, Diffusion Profiles, Pre-Deposition and Drive-In Ion implantation, Understanding Terminology in Ion Implantation - Dosage, Range, Straggle, Scattering of Dopants Doping profile, Diffusion vs Ion Implantation, Selection of Doping Techniques based on Application; Lithography – Pattern transfer techniques, Pattern transfer: Direct writing – Laser writing, Direct Printing – Imprint or Molding, Indirect Writing – Electron-Beam Lithography, Indirect Printing – Optical Lithography, Modes of Photolithography: Contact, Proximity and Projection Lithography, Different Laser Sources used for Optical Lithography and Implications on Feature Size and Device Packing Density, Photoresists: Positive and Negative Photoresists, Masks: Bright Field and Dark Field Masks, Tools in Photolithography: Fume Hood, Spin Coater, Hotplates, Ovens, Mask Aligner Systems, and Wet Benches; Etching – Wet and Dry Etching, Understanding Terminology in Etching: Isotropic, Anisotropic and Directional Processes, Wet Etching: Etching of Metals, Semi-Conductors and Insulators, Lift-Off Process, Dry Etching Process: Plasma Assisted Etch Process, Reactive Ion Etching (RIE) and Deep Reactive Ion Etching (DRIE), Selection of Etching Process for Specific Device: Design Considerations, Process Time, and Precautions; Fabrication of Micro-Engineered Devices: Process Flow of Device Fabrication using Semiconductor Wafers, PMOS, NMOS, and CMOS Fabrication Processes, Fabrication of Multiple Sensors on a Single Wafer using Multi-Mask Process, Device Fabrication using Soft Lithography; System Integration of Microsensors and Devices: Data Acquisition Systems Integrate with Signal Conditioning Circuits for Interfacing Sensors and Devices, Case Studies: Overview of Commercial-Of-The-Shelf (COTS) DAQ Systems, Electronic System Integration for ECG Signal Acquisition, Conditioning, and Processing to Compute BPM (Beats per minute), Signal conditioning Circuit for Operating Heater Voltage of Commercial Gas Sensors, Excitation Circuit for Maintaining Temperature of Micro-Heaters, Calibration and Interfacing of Force Sensors; Lab Component: Familiarization with Gowning Procedure and Safety Protocols, Introductory Clean Room Visit and Overview of Equipment, Hands-On-Training on Wafer Cleaning Processes: RCA1, RCA2 and Piranha Cleaning, Thermal Evaporation of Metals, E-beam Evaporation of Metals and Insulators, Photolithography: Photoresist Coating, Soft Bake, UV Exposure using Mask Aligner System, Development, Hard Baking, and Litho-Inspection, Wet Etching of Metals, Semiconductors and Insulators, Device Fabrication: From Si to Microchips, Soft Lithography: Microfluidic Device Fabrication by Poly Dimethyl Siloxane (PDMS) Mold

Hardik J Pandya

References:

- Fundamentals of Microfabrication by Madou Marc J.
- Silicon VLSI Technology: Fundamentals, Practice, and Modeling by James D. Plummer, Michael Deal, and Peter D. Griffin
- Fundamentals of Semiconductor Fabrication by S M Sze
- VLSI Fabrication Principles: Silicon and Gallium Arsenide by S K Gandhi
- VLSI Technology by S M Sze
- Fundamentals of Microelectronics by B Razavi
- Franco, S., 2002. Design with operational amplifiers and analog integrated circuits. New York: McGraw-Hill.
- Pallas-Areny, R. and Webster, J.G., 2012. Sensors and signal conditioning. John Wiley & Sons.

Pre-requisites:
- Basic Electronics

E6 202 (JAN) 2:1

Design of Power Converters

Power semiconductor switches, drive circuits for MOSFETs and IGBTs, snubber circuits, rectifier circuits, dc-dc switched mode converter circuits, pulse width modulation, non-isolated and isolated converters, magnetics for switched mode power conversion, design of magnetics, magnetic amplifiers, inverter circuits-self oscillating and driven inverter circuits, efficiency and losses in power electronic circuits, thermal issues and heat sink calculation.

Umanand L

References:
- Mohan N, Undeland T M, Robbins W P, Power Electronics: Converters, Applications and Design, John Wiley and Sons, NY, USA,Kitsum K, Switched Mode Power Conversion - Basic Theory and Design, Marcel Dekker, Inc, NY, USA,Rashid M H, Power Electronics, Circuits, Devices and Applications, Prentice Hall, NJ, USA

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

References:
- Leonhard W, Control of Electrical Drives, Springer-Verlag, 1985,Mohan N, Undeland T M, Robbins, W P, Power electronics : Converters, Drives and application, John Wiley, NY, USA,Umanand L, Power electronics : Essentials and applications, Wiley India, 2009

E9 253 (JAN) 3:1

Neural Networks and Learning Systems

Introduction, models of a neuron, neural networks as directed graphs, network architectures (feed-forward, feedback etc.), Learning processes, learning tasks, Perceptron, perceptron convergence theorem, relationship between perceptron and Bayes classifiers, batch perceptron algorithm, modeling through regression: linear, logistic for multiple classes, Multilayer perceptron (MLP), batch and online learning, derivation of the back propagation algorithm, XOR problem, Role of Hessian in online learning, annealing and optimal control of learning rate, Approximations of functions, universal approximation theorem, cross-validation, network pruning and complexity regularization, convolution networks, nonlinear filtering, Cover’s theorem and pattern separability, the interpolation problem, RBF networks, hybrid learning procedure for RBF networks, Kernel regression and relationship to RBFs., Support vector machines, optimal hyperplane for linear separability, optimal hyperplane for non-separable patterns, SVM as a kernel machine, design of SVMs, XOR problem revisited, robustness considerations for regression, representer theorem, introduction to regularization theory, Hadamard’s condition for well-posedness, Tikhonov regularization, regularization networks, generalized RBF networks, estimation of regularization parameter etc., L1 regularization basics, algorithms and extensions, Principal component analysis: Hebbian based PCA, Kernel based PCA, Kernel Hebbian algorithm, deep MLPs, deep autoencoders, stacked denoising auto-encoders

Shayan Garani Srinivasa

References:

- S. Haykin, Neural Networks and Learning Machines, Pearson Press.
- K. Murphy, Machine Learning: A Probabilistic Perspective, MIT Pres

EP 299 (JAN) 0:25

Dissertation Project

Dissertation Project

Chandramani Kishore Singh

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 characterization 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 also offers an M Tech Programme in Transportation and Infrastructure 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

Chair

Division of Mechanical Sciences

Aerospace Engineering MTech Curriculum

Semester I	Semester 2	Semester 3	Semester 4
Flight and Space Mechanics	Math requirement either in the 2nd or 3rd 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	
Navigation, Guidance and Control	Elective 4	Elective 8	
Experimental Techniques in Aerospace Engineering		MTech Dissertation distributed over 3rd and 4th semesters	
16 credits	48 credits (Minimum 12 credits per semester)		

The core courses include Flight and Space Mechanics, Fluid Dynamics, Mechanics and Thermodynamics of Propulsion, Flight Vehicle Structures, and Navigation, Guidance and Control.

Math requirement can be math courses offered in the Aerospace Engineering Department, or courses from Math Department IISc, or courses from Center for Data Sciences IISc. A list of courses that fulfills the math requirement will be listed separately by the AE DCC.

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.

Aerospace Seminar is a 1 credit course in the 4th semester. This course will have lectures by AE faculty as well as lectures by staff from Archives and Publications Cell on best practices in scientific written and oral communication. Thereafter the MTech students will present a report and seminar during the 4th semester on a topic chosen in consultation with their faculty advisor. These seminar reports and presentations will be evaluated by an AE faculty panel.

Special Topics in Aerospace Engineering 1 and Special Topics in Aerospace Engineering 2 are two electives of an advanced nature on topics of current research being pursued by AE faculty. These courses will be offered by interested AE faculty. These elective courses will be open to all students in the Institute and pre-requisites for registering for these electives will be with instructor's consent.

The MTech dissertation project is aimed at training students to analyze 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.

MTech Dissertation adviser to be chosen by the MTech student at the end of the first semester. Math requirement, all electives, and the independent study course, will be credited by a student in consultation with the MTech dissertation adviser. In keeping with IISc MTech program requirement, AE MTech students should register for a minimum of 12 credits per semester.

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.

Ranjan Ganguli

References:

- 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.

Ramesh O N

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 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.

Pratikash Prakash Panda

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 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.

Debiprosad Roy Mahapatra

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 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, Suresh Sundaram

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 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)

Pre-requisites:
- AE 227

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

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.

Pre-requisites:

- AE 203 or AE 241 or AE 242 or AE 243, or equivalent. These can however be waived after discussion with the course instructors.

AE 256 (AUG) 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 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 291 (AUG) 3:0

Special topics in aerospace engineering 1

This elective will be of an advanced nature on topics of current research being pursued by AE faculty.This course will be open to all students in the Institute.

Kartik Venkatraman

Pre-requisites:

- Instructor’s consent is required before registering for this course.

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.

Siddanagouda Kandagal, Duvvuri Subrahmanyam

AE 211 (JAN) 3:0

Mathematical methods for aerospace engineers

Ordinary differential equations; Elementary numerical methods; Finite differences; Topics in linear algebra; Partial differential equations.

Joseph Mathew, Arnab Samanta

References:

- Erwin Kreysig, Advanced Engineering Mathematics Wiley 2015.

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

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.

Pre-requisites:

- AE 202

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

References:

- Liepmann, H.W. and Roshko, A., Elements of Gas Dynamics, John Wiley, 1957.
- Becker, E., Gas Dynamics Academic Press, New York, 1968.
- Anderson, J.D., Modern Compressible Flow, McGraw Hill, 1990.
- Zucrow, M.J. and Hoffman, J.D., Gas Dynamics, Vols. 1-2, Wiley, 1976.
- Zucker, R.D. and Biblarz, O., Fundamentals of Gas Dynamics, Wiley, 2002.

Pre-requisites:

- AE 202

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

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.

Pre-requisites:

- AE 202 or equivalent

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

References:

- 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.

Pre-requisites:

- AE 202 or equivalent.

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

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.

Pre-requisites:

- AE 202, AE 222, courses in Numerical Analysis/Numerical Methods, and any programming language.

AE 231 (JAN) 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.

Sourabh Suhas Diwan, Srisha Rao M V, Duvvuri Subrahmanyam

References:

- William H Roe Jr., and Alan Pope, Low Speed Wind Tunnel Testing Wiley and Sons, 1984.
- Pankhrust, 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.

Pre-requisites:

- AE 202 or equivalent

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.

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 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.

Pre-requisites:

- A course in solid or fluid mechanics.

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

References:

- Sharpe, R.A., Research Techniques in NDT, Metals Handbook -Vol.17.

Pre-requisites:

- AE 204 or equivalent.

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 271 (JAN) 3:0

Guidance Theory and Applications

Design process, airworthines, safety, environmental issues, requirements,overall configuration and systems, fuselage layout, wing and tail design, mass and balance, power plant selection, landing gear layout, aircraft performance cost estimation, and initial design and sizing

Debasish Ghose, Ashwini Ratnoo

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.

Pre-requisites:

- AE 205 or equivalent

AE 274 (JAN) 3:0

Topics in Neural Computation

Foundation of neural networks: perceptron, multi-layer perceptron, radial basis function network, recurrent neural network; Evolving/online learning algorithms; Deep neural networks: Convolutional neural network, restricted Boltzmann machine; Unsupervised learning; Advanced topics: Reinforcement learning and deep-reinforcement learning; Spiking neural network--- spiking neuron, STDP, rank-order learning, synapse model, SEFRON.

Suresh Sundaram

References:

- S. Haykin, Neural Networks, Pearson Education, 2ed, 2001.

Pre-requisites:

- Knowledge of algebra, numerical methods, calculus and familiarity with programming in Python and MATLAB.

AE 292 (JAN) 3:0

Special topics in Aerospace Engineering 2

This elective will be of an advanced nature on topics of current research being pursued by AE faculty.This course will be open to all students in the Institute.

Kartik Venkatraman

Pre-requisites:

- For registering this course Instructors consent is required

AE 299 (JAN) 0:20

Dissertation Project

The MTech dissertation 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 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.

Joseph Mathew

AE 371 (JAN) 3:0

Applied Nonlinear Control

Introduction and motivation, phase plane analysis, mathematical preliminaries. Review of functional analysis, topology and matrix theory; Lyapunov stability theory: autonomous systems; back-stepping design; dynamic inversion (feedback linearization). Applications of neural networks in control system design, neuro-adaptive control, nonlinear observers, Lyapunov stability theory: non-autonomous systems, adaptive control, advanced nonlinear flight control.

Radhakant Padhi

References:

- Marquez, H.J., Nonlinear Control Systems Analysis and Design, Wiley, 2003.
- Slotine, J.J.E., and Li, W., Applied Nonlinear Control, Prentice Hall, 1991.
- Khalil, H. K., Nonlinear Systems, Prentice Hall, 1996.
- Behera, L., and Kar, I., Intelligent Systems and Control, Oxford Univ. Press, 2009.
- Lecture Notes.

Pre-requisites:

- AE 205 and 272 or equivalent; familiarity with MATLAB

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; 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

References:

- Naidu, D.S., Optimal Control Systems, CRC Press, 2002.
- Sinha, A., Linear Systems: Optimal and Robust Control, CRC Press, 2007
- Bryson, A.E., and Ho, Y-C, Applied Optimal Control, Taylor and Francis, 1975.
- Stengel, R.F., Optimal Control and Estimation, Dover Publications, 1994.
- Sage, A.P., and White, C.C. III, Optimum Systems Control, 2nd Ed., Prentice Hall, 1977.
- Kirk, D.E., Optimal Control Theory: An Introduction, Prentice Hall, 1970. Lewis, F.L., Optimal Control, Wiley, 1986.
- Lecture Notes.

Pre-requisites:

- AE 205 or equivalent and familiarity with MATLAB

Centre for Atmospheric and Oceanic Sciences (CAOS)

CAOS

Preamble:

The Centre for Atmospheric Sciences was established in 1982 and renamed Centre for Atmospheric and Oceanic Sciences in 1996. Known for pioneering work on monsoon physics and variability, its activities now span a broad range of topics in atmosphere, ocean and climate science.

Core Research:

CAOS faculty and students study the monsoons and tropical climate variability, cloud physics and tropical convection, space-time variations of rainfall and extreme rain events, the hydrological cycle, physical oceanography and air-sea interaction, nonlinear climate dynamics, the planetary boundary layer, aerosol physics and chemistry, radiation and climate, large-scale waves and geophysical turbulence, climate change, the carbon cycle and geoengineering. In addition to ocean and climate modelling, data analysis and theoretical work, the Centre has a long tradition of field campaigns to study physical processes from *in situ* measurements on land and in the atmosphere and ocean.

Current Research:

We highlight a few results to convey a flavour of research at CAOS. Analysis of IMD radar observations have revealed distinct convective cells ("storms") buried within the widespread cloud cover of the monsoon. Each storm comprises of clusters of cumulonimbus clouds, tens to hundreds of square kilometres in area and lifespan of 30 minutes to 3 hours. Very heavy rainfall is associated with storms, and the outflow from the storms merge in the upper troposphere to produce extensive cloud cover.

The Bay of Bengal plays a fundamental role in the birth of monsoon weather systems. The BoB Boundary Layer Experiment (BoBBLE) was undertaken by India and the United Kingdom in June-July 2016. Physical and biogeochemical observations showed the time evolution of the Sri Lanka dome and the summer monsoon current, and two freshening events when upper ocean salinity decreased, leading to thick barrier layers. These observations, made during a suppressed phase of the monsoon intraseasonal oscillation, captured ocean warming and preconditioning of the atmosphere to convection.

Remote forcings ("teleconnections") have important implications for seasonal prediction of rainfall over India. It has been shown how these forcings can affect monsoon rainfall. For example, if the previous winter was a La Nina, the rainfall during the current summer over India would decrease slightly. Furthermore, if the present summer is El Nino, last winter's La Nina increases the probability of drought. These remote effects on the monsoon are manifest slowly, due to the slow propagation of surface pressure anomalies in subtropics as ENSO changes its state with season.

The atmospheric concentration of methane (CH_4) has increased by almost 150 % since the pre-industrial period, contributing ~20% to the total anthropogenic greenhouse gas radiative forcing. Recent work in the centre has investigated the effectiveness of CH_4 in global warming per unit of radiative forcing. Idealized model simulations indicate that the effectiveness of CH_4 is nearly ~80% of the role of CO_2, and this is related to shortwave absorption bands of CH_4.

Black carbon (BC) in the atmosphere does not only exert a warming effect, it also influences Free-Space Optical communication links. Atmospheric warming by an elevated BC-layer at altitude of around 4.5 km enhances atmospheric stability, leading to large reductions in the atmospheric refractive index structure parameter. This alleviates the attenuation of the signal by BC, leading to fewer link outages. The net effect is improvement in wavelength transmission and thus fewer adaptive optics units are required to manage communication systems.

We estimate spatial averages from point observations all the time, but this is not straightforward. With the possibility of missing data, the spatial average is a ratio between random variables. We have extended optimal averaging theory to situations where individual observations might be missing, by deriving convergent series approximations for the bias and variance. We have applied this theory to understand uncertainty in spatial averages of rain-gauge derived precipitation estimates over India, for e.g. Indian Summer Monsoon Rainfall.

In the area of geophysical fluid dynamics, observational data of sea-surface height has been used to understand midlatitude surface ocean dynamics at scales near the local deformation radius, i.e., 200 km to 100 km, where Earth's rotational effects become important. Calculations of energy and enstrophy fluxes and kinetic energy spectra, from estimated geostrophic currents, compare favourably with corresponding results from a comprehensive Earth system model. These calculations appear to reveal a rotationally dominated portion of a surface oceanic counterpart of the Nastrom-Gage spectrum that describes upper-tropospheric energy and enstrophy cascades in the atmosphere.

In the area of physical oceanography, we have understood the mechanisms of movement and dispersal of river water in the Bay of Bengal with the help of satellite-derived sea surface salinity and surface currents.

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

References:

- 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 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

Pre-requisites:

- 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

References:

- 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 207 (AUG) 3:0

Introduction to Atmospheric Dynamics

Jai Suhas Sukhatme

AS 216 (AUG) 3:0

Introduction to Climate System

Equations of motion for the atmosphere and oceans, observed mean state of the atmosphere and oceans, exchange of momentum, energy and water between the atmosphere and surface, angular momentum cycle, global water cycle, radiation, energetics, entropy in climate system, climate variability, The global carbon cycle, Climate System Feedbacks

Govindasamy Bala

References:

- J. Peixoto and A.H. Oort,Physics of Climate,,American Institute of Physics

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

References:

- 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.

Satheesh S K

References:

- 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

References:

- 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

References:

- Thomas T Warner,Numerical Weather and Climate Prediction,Cambridge University Press,2011,John B Drake

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

References:

- 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.
- Harrison R. G. Meteorological Measurements and Instrumentation Wiley, (2014)
- DeFelice, T. P., An Introduction to Meteorological Instrumentation and Measurement. Prentice Hall, 1998

AS 299 (JAN) 0:28

Project

AS 308 (JAN) 2:1

Ocean Modeling

Equations governing ocean dynamics and thermodynamics, approximations, initial and boundary conditions, one dimensional ocean models: bulk shearinstability and turbulent closure models reduced gravity ocean models, Primitive equation models of ocean circulation. Sub-grid scale process, mixed layer parameterization, sigma coordinate models finite difference schemes, time differencing, convergence and stability, testing and validation test Problems. P.N.Vinayachandran

Vinayachandran P N

References:

- Kowalik,Z and murthy, T.S., Numerical Modeling of Ocean Dynamics, World Scientific, 1995.
- Kantha,L.H. Clayson, C.A., Numerical Models of Oceans and Oceanic Processes, International Geophysic Series,Vol.66, Academic Press, NY2000.
- Haidvogel,D.b., and Beckmann, A.BNumerical OceanCirculation Modeling, Imperial College Press, 1999.
- Chassignet and Vernon J.(ED), Ocean Modeling and Parameterization.
- NATO Advanced Study Institute, Kluwer Academics, 1988.

CIVIL ENGINEERING

Syllabus for M Tech Civil Engineering and
M Tech Transportation and Infrastructure Engineering program (2019-20)

M Tech Program in Civil Engineering

Semester 1 Common to all students

Core: 18 Credits

CE 201 3:0 Basic Geomechanics
CE 202 3:0 Foundation Engineering
CE 203 3:0 Surface Water Hydrology
CE 204 3:0 Solid Mechanics
CE 205 3:0 Finite Element Method
CE 211 3:0 Mathematics for Engineers

a) **To fulfill Major requirement in an Area,** students shall complete minimum 21 course credits (15 core + 6 elective on offer) and 22 Dissertation project credits in the said Area.
b) **For optional Minor in one of the other two Areas**, a student must complete minimum of 12 credits in the said Area.

Major in Geotechnical Engineering

Core: 9 Credits

CE 206 3:0 Earth and Earth Retaining Structures
CE 207 3:0 Geoenvironmental Engineering
CE 208 3:0 Ground Improvement and Geosynthetics
CE 299 0:22 Dissertation Project

Major in Structural Engineering

Core: 9 Credits

CE 209 3:0 Mechanics of Structural Concrete
CE 210 3:0 Structural Dynamics
CE 228 3:0 Continuum Plasticity
CE 299 0:22 Dissertation Project

Major in Water Resources Engineering

Core: 12 Credits

CE 212 3:0 Computational Fluid Dynamics in Water Resources Engineering
CE 213 3:0 Systems Techniques in Water Resources Engineering
CE 214 3:0 Ground Water Hydrology
CE 215 3:0 Stochastic Hydrology
CE 299 0:22 Dissertation Project

Electives in Geotechnical Engineering

CE 220 3:0 Design of Substructures
CE 221 3:0 Earthquake Geotechnical Engineering
CE 222 3:0 Fundamentals of Soil Behaviour
CE 227 3:0 Engineering Seismology
CE 231 3:0 Forensic Geotechnical Engineering

Electives in Structural Engineering

CE 216 3:0 Random Vibration and Reliability Analyses
CE 218 3:0 Fire structural engineering
CE 229 3:0 Non-Destructive Evaluation Methods for Concrete Structures
CE 235 3:0 Optimization Methods
CE 236 3:0 Fracture Mechanics
CE 239 3:0 Stochastic Structural Dynamics
CE 243 3:0 Bridge Engineering
CE 297 3:0 Problems in the Mathematical Theory of Elasticity
CE 298 3:0 Parallel computing in mechanics problems

Electives in Water Resources Engineering

CE 226 3:0 Open-channel Flow
CE 245 3:0 Design of Water Supply and Sewerage Systems
CE 247 3:0 Remote Sensing and GIS for Water Resources Engineering
CE 248 3:0 Regionalization in Hydrology and Water Resources Engineering
CE 249 3:0 Water Quality Modelling
ME 201 3:0 Fluid Mechanics
AS 216 3:0 Introduction to Climate Systems

M Tech Program in Transportation and Infrastructure Engineering

Core: 24 Credits

CE 235 3:0 Optimization Methods
CE 262 3:0 Public Transport System Planning
CE 269 3:0 Traffic Engineering
CE 270 3:0 Travel Demand Modeling
CE 272 3:0 Traffic Network Equilibrium
CE 274 3:0 Sustainable Urban Transportation Planning
CE 211 3:0 Mathematics for Engineers

One 3:0 credit core course from either Geotechnical Engineering/ Structural Engineering/ Water Resources Engineering

CE 299 0:22 Dissertation Project

Electives: 18 Credits of which at least 9 credits should be from among the electives listed below.

CE 202 3:0 Foundation Engineering
CE 208 3:0 Ground Improvement and Geosynthetics
CE 209 3:0 Mechanics of Structural Concrete
CE 247 3:0 Remote Sensing and GIS for Water Resources Engineering
CE 271 3:0 Choice Modeling
CE 273 3:0 Markov Decision Processes
MA 261 3:0 Probability Models
ST 202 3:0 Renewable Energy - Technology, Economics and Environment
ST 203 3:0 Technology and Sustainable Development
MG 221 3:0 Applied Statistics
DS 290 3:0 Modeling and Simulation

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

References:
- Wood,D.M.,Soil Behaviour and Critical State Soil Mechanics,Cambridge University Press,1991.

CE 202 (AUG) 3:0

Foundation Engineering

Subsurface investigations. 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.

Anbazhagan P

References:
- Bowles,J.W.,Foundation Analysis and Design,5th Edn.,McGraw-Hill
- Das, M. B., Principles of Foundation Engineering, Brooks/Cale Engineering Division, 1984.

Pre-requisites:
- B.E/ B.Tech - Soil Mechanics - Course Completion

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

References:
- Bedient, P. B., and Huber, W. C., Hydrology and Floodplain Analysis, Prentice Hall, 2002.
- Chow, V.T., Maidment, D.R. and Mays, L.W,. Applied Hydrology, McGraw-Hill 1988
- Linsley, R.K., Kohler, M.A. and Paulhus, J.L.H., Hydrology for Engineers, McGraw Hill, 1985.

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

References:

- 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

Pre-requisites:

- No specific prerequisite course, but a good grasp of undergraduate multi-variable calculus, linear algebra and Strength of Materials is highly recommended

CE 205 (AUG) 3:0

Finite Element Method

Concepts of the stiffness method. Energy principles. Continuum BVP and their integral formulation. Variational methods: Raleigh-Ritz, weighted residual methods, virtual work and weak formulations. Finite element formulation of one, two and three dimensional problems, Isoparametric formulation. Computational aspects and applications, Introduction to non-linear problems.

Chandra Kishen J M

References:

- Zienkiewicz, O.C. and Taylor, R.L., The Finite Element Method: Vol. 1 (The Basis), Butterworth-Heinemann, 2000.
- Cook R.D.. Malkus, D. S., Plesha and Witt, R.J., Concepts and Applications of Finite Element Analysis, Fourth edition, John Wiley and Sons.
- J N Reddy, An Introduction to the Finite Element Method, Second Edition, McGraw Hill Inc, 1993.

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.

Debraj Ghosh, Tarun Rambha

References:

- Michael Stone,Paul Goldbart,2009,Mathematics for Physics: A Guided Tour for Graduate Students,Cambridge University Press
- Probability, Random Variables and Stochastic Processes, A Papoulis and S U Pillai
- Linear Algebra and Its Applications by Gilbert Strang

CE 216 (AUG) 3:0

Random Vibration and Reliability Analyses

Review of probability: probability space and random variables. Review of random processes: stationarity, ergodictiy, power spectrum and autocovariance. Calculus of random processes. Input-output relations for linear systems. Stochastic steady state. Level crossing and first passage problems. Extreme value distributions. Reliability index based analyses: FORM and SORM. Monte Carlo simulations and variance reduction. Reliability of existing structures.

Manohar C S

References:

- A Papoulis, 1991, Probability, random variables and stochastic processes, 3rd Edition, McGraw-Hill, New York
- N C Nigam, 1983, Introduction to random vibrations, MIT press, Cambridge
- R E Melchers, 1999, Structural reliability: analysis and prediction, 2nd Edition, John Wiley, Chichester.

Pre-requisites:

- Background in structural dynamics and theory of probability

CE 218 (AUG) 3:0

Fire structural engineering

Role of structural engineering in fire safety. Introduction to fire dynamics. Models for enclosure fire dynamics. Review of heat transfer and thermo elasticity. Material properties at elevated temperature. Behavior of beams, columns, walls, and slabs at elevated temperature. Thermal buckling. Finite element modeling of structures under fire. Treatment of material and geometric nonlinearities. Joint behavior. Modeling of building frames under fire. Review of fire resistant design. Treatment of uncertainties and concepts of performance based design.

Manohar C S

References:

- A H Buchanan, 2002, Structural design for fire safety, Wiley, Chichester.
- Y Wang, I Burgess, F Wald, and M Gillie, 2013, Performance-based fire engineering of structures, CRC Press, Boca Raton.
- D Drysdale, 1998, An introduction to fire dynamics, 2nd Edition, Wiley, Chichester.
- B Karlsson, and J Quintiere. 1999, Enclosure fire dynamics. CRC press, Boca Raton
- J G Quintere, 2006, Fundamentals of fire phenomenon. John Wiley, Chichester.

Pre-requisites:

- Basic course in solid mechanics.

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

References:

- Bowles,J.E. Foundation analysis and design. 5th Edn.,McGraw Hill,1996
- Indian 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

References:

- Geotechnical Earthquake Engineering By Steven L. Kramer, Pearson Education, 2003
- Geotechnical Earthquake Engineering Handbook, Robert W. Day, McGraw-Hill, 2002.
- Current Literature

CE 226 (AUG) 3:0

Open-channel Flow

Basic Concepts of Fluid Mechanics Introduction to Open-channel Flow Uniform Flow Non-uniform Flow: Gradually Varied Non-uniform Flow: Rapidly Varied Spatially Varied Flow Unsteady Flow Pollutant Transport in Open Channels

Mujumdar P P

References:

- Te Chow, Ven. Open-channel hydraulics. Vol. 1. New York: McGraw-Hill, 1959.
- Chaudhry, M. Hanif. Open-channel flow. Springer Science & Business Media, 2007.
- Srivastava, Rajesh. Flow through open channels. Oxford Higher Education, 2008.

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

References:

- Bolton M (1991) A Guide to Soil Mechanics, Universities Press
- Robert W. Day (2011) Forensic Geotechnical and Foundation Engineering, Second Edition, McGraw-Hill Companies, Inc.
- Rao, V.V.S. and Sivakumar Babu, G.L (2016) Forensic Geotechnical Engineering, Springer Nature.

CE 236 (AUG) 3:0

Fracture Mechanics

Introduction; Linear Elastic Fracture Mechanics; Design based on LEFM; Elasto-Plastic Fracture

Mechanics; Mixed Mode Crack Propagation; Fatigue Crack Propagation; Finite Elements in Fracture Mechanics.

Remalli Vidya Sagar

References:

- T. L. Anderson, Fracture Mechanics, CRC press, Fourth Edition, 2017, Boca Raton, Florida
- David Broek, Elementary Fracture Mechanics, Sijthoff and Noordhoff, The Netherlands.
- Prashanth Kumar, Elements of Fracture Mechanics, Wheeler Publishing, New Delhi.
- J. F. Knott, Fundamentals of Fracture Mechanics, Butterworths, London.

CE 243 (AUG) 3:0

Bridge Engineering

Bridge types, aesthetics, general design considerations and preliminary design, IRC/ AASHTO design loads, concrete bridge design - reinforced and prestressed girder bridges, steel bridge design Composite bridges, design of bridge bearings, Pier, Abutment and foundation; seismic and wind load analysis, analysis of cable supported bridge systems, bridge inspection and maintenance.

Ananth Ramaswamy

References:

- Barker and Puckett Design of Highway Bridges, John Wiley and Sons 2007

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

References:

- Mark J Hammer & Mark J Hammer Jr.,Water and Wastewater Technology,Fifth Edition,Pearson Prentice Hall,Columbus, USA, 2004.

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. Water Resources Assessment, Irrigation management. Vegetation monitoring. Drought and flood monitoring, Introduction to digital elevation modeling (DEM) and Global Positioning System (GPS). Use of relevant software for remote sensing and GIS applications.

Nagesh Kumar D

References:

- Remote Sensing and Image Interpretation, T.M. Lillesand and R.W. Kiefer, John Wiley & Sons, 2000.
- Remote Sensing - Principles and Interpretation, F.F. Sabins Jr, W.H. Freeman & Co., New York, 1986.
- An Introduction to Geographical Information Systems, I. Heywood, S. Cornelius and S. Carver, Pearson Education, 1998.
- Remote sensing in water resources management: The state of the art, Bastiaanssen, W.G.M., International Water Management Institute, Colombo, Sri Lanka, 1998.

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

References:

- Chapra,S.C.,Surface Water Quality Modeling,McGraw Hill,1997.
- Tchobanoglous, G., and Schroeder, E.D., Water Quality, Addison Wesley, 1987.

CE 269 (AUG) 3:0

Traffic Engineering

Traffic flow elements and its characterization: vehicle characteristics, human factors, infrastructure elements, capacity and LoS concepts, Highway Capacity Manual (HCM) methods. Uninterrupted Traffic Flow: speed-flow-density relationships, multi-regime models, car-following, lane-changing, simulation framework. Interrupted Traffic Flow: signal design, shock-wave theory, gap-acceptance behavior, delay and queue analysis. Design of traffic facilities: expressways, signalized and un-signalized intersections, interchanges, parking, signs and markings.

Tarun Rambha

References:

- 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 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

References:

- 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

Discrete time Markov chains; Transient and limiting behavior; Finite horizon MDPs; Backward induction; Infinite horizon models; Discounted, average, and total cost MDPs; Value and policy iteration; Linear programming methods; Approximate dynamic programming; Reinforcement learning; Dynamic discrete choice models; Applications to shortest paths, airline ticketing, dynamic pricing, adaptive signal control, and demand estimation.

Tarun Rambha

References:

- 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 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

References:

- 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.

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

References:

- Sharma, H.D., and Reddy, K.R., Geoenvironmental Engineering: Site Remediation, Waste Containment and Emerging Waste Management Technologies, John Wiley & Sons, Inc., Hoboken, New Jersey, 2004.
- Rowe, R. Kerry, Quigley, Robert M., Brachman, Richard W. I., and Booker, John R. Barrier Systems for Waste Disposal Facilities , 2nd edn 2004. Spon Press, Taylor & Francis Group, London.
- Tchobanoglous, G., Theisen, H. and Vigil, S.A., Integrated Solid Waste Management - Engineering Principles and Management Issues, McGraw Hill (1993).

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

References:

- 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.Dover Publications, New York

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.

Ananth Ramaswamy

References:

- Nilson, A. H., Darwin, D. and Dolan, C. W., Design of concrete structures, McGraw Hill, 2004
- Lin and Burns, Design of Prestressed concrete structures, John Wiley and Sons, 2006
- Agarwal and Shrikhande- Earthquake resistant design of structures, Prentice-Hall of India Pvt. Ltd. New Delhi, 2006.

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

References:

- 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 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

References:

- Computational Fluid Dynamics: Applications in Environmental Hydraulics,edited by Paul D. Bates,Stuart N. Lane,Robert I. Ferguson,Wiley; 1st edition

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

References:

- 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.

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

References:

- Freeze,A. R. and Cherry,J. A. Groundwater,Prentice Hall,1979.
- Fetter, C. W. Applied Hydrogeology, Prentice Hall, 1988.
- Domenico, P. A., and Schwartz, F. W. Physical and Chemical Hydrogeology, John Wiley, 1990. Fetter, C. W. Contaminant Hydrogeology, Prentice Hall, 1993.

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

References:

- 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 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

References:

- Earthquake Engineering – From Engineering Seismology to Performance Based Engineering,Edited by Bozorgnia,Y. and Bertero,V.V.,CRC Press Washington 2004.

CE 228 (JAN) 3:0

Continuum Plasticity

Brief reviews of finite deformation kinematics and constitutive closure; introduction to rational thermodynamics and formulation of constitutive theories; internal variables; dissipation inequality; physics of yielding; plastic flow and hardening; notion of yield surface; classical models for yielding; plastic flow and hardening; additive and multiplicative splitting of kinematic quantities; solutions of simple BVPs; FEM for small deformation plasticity; yield free plasticity models; linearization and computational schemes; introduction to damage mechanics

Debasish Roy

References:

- A S Khan, S Huang, 1995, Continuum Theory of Plasticity, John Wiley, NY
- J Lubliner, 2008. Plasticity theory. Courier Corporation.
- M E Gurtin, L Anand, 2012, The Mechanics and Thermodynamics of Continua, Cambridge University Press, UK
- Simo, J. C., & Hughes, T. J., 2006, Computational inelasticity, Springer Science & Business Media.

Pre-requisites:

- A graduate level course in solid mechanics or continuum mechanics.

CE 229 (JAN) 3:0

Non-Destructive Evaluation Methods for Concrete Structures

Planning and interpretation of in-situ testing of concrete structures; Surface hardness methods; Fundamental bases and methodologies of non-destructive evaluation (NDE) techniques related to concrete structures; NDE methods for concrete testing based on sounding: Acoustic emission (AE) testing of concrete structures; NDE methods for concrete testing based on sounding: Ultrasonic pulse velocity (UPV) methods; Partially destructive strength tests related to concrete; cores; Examples of UPV corrections for reinforcement; examples of evaluation of core results

Remalli Vidya Sagar

References:
- J. H. Bungey and S. G. Millard (1996) Testing of concrete in structures. Blackie Academic & Professional, 1996, chapman & Hall publishers.
- V. M. Malhotra and N. J. Carino (2005) Handbook on Nondestructive Testing of Concrete Ed. by V.M. Malhotra and N.J. Carino., CRC publishers.
- C. V. Subramanian (2016) Practical Ultrasonics., Narosa publishers
- C. U. Gross and M. Ohtsu (2008) Acoustic Emission Testing., Springer-Verlag Berlin Heidelberg
- JSNDI (2016) Practical Acoustic Emission testing. Springer Japan 2016.

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

References:
- Arora, J.S. Introduction to Optimization, McGraw-Hill (Int. edition)1989.
- Rao, S.S., Optimization: Theory and Applications. Wiley Eastern, 1992
- Current Literature.

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

References:
- Lin, Y K, Probabilistic Structural Dynamics, McGraw-Hill
- Kloeden, P.E. and Platen, E., Numerical Solutions of Stochastic Differential Equations, Springer
- Ghanem, R.G and Spanos, P D, Stochastic Finite Elements: A Spectral Approach, Springer-Verlag.

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

References:

- Diekkrüger, B., Schröder, U., Kirkby, M. J., Regionalization in Hydrology, IAHS Publication no. 254, 1999.
- Hosking, J. R. M., and Wallis, J. R., Regional Frequency Analysis: An Approach Based on L-Moments, Cambridge University Press, 1997.
- Rao, A.R. and Srinivas, V.V., Regionalization of Watersheds - An Approach Based on Cluster Analysis, Series: Water Science and Technology Library, Vol. 58, Springer Publishers, 2008.

Pre-requisites:

- CE 203

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

References:

- 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 271 (JAN) 3:0

Choice Modeling

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

References:

- 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.
- M. Ben-Akiva & S.R. Lerman. Discrete Choice Analysis: Theory and Application to Travel Demand, MIT Press, 1985.

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

References:

- 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 297 (JAN) 3:0

Problems in the Mathematical Theory of Elasticity

Introduction: Review of linear elasticity, equilibrium, compatibility, statements of 2D (plane strain / plane stress) and 3D elastic BVPs, Review of Airy stress functions. Functions of a complex variable: Introduction to holomorphic and sectionally holomorphic functions. Laurent series, contour integrals, generalized Cauchy integral formulae. Bi-harmonic equation in the complex plane. Kolosov-Muskhelishvili formulation for planar elasticity. Conformal mapping. The Riemann-Hilbert problem. Analysis of selected problems using complex variable methods: Plate with an elliptic hole. The slit infinite plane. Singular and distributed solutions for halfplanes, disks, and plates with holes. Contact of a rigid punch and halfplane. Multivalued displacements and disloca-tions. 3D linear elasticity problems: Papkovich-Neuber formulation. Boussinesq potentials. Kel-vin's problem. The Boussinesq solution. The Hertz contact problem. Galin's theorem. Introduction to micromechanics: Eshelby's ellipsoidal inclusion problem. Planar inclusions. Other topics as time permits (e.g. anisotropic elasticity)

Narayan K Sundaram

References:

- Current and historic literature

Pre-requisites:

- Graduate-level solid mechanics (CE-204 / ME-242 or equivalent) with a grade of B or higher, or instructor consent.

CE 298 (JAN) 3:0

Parallel computing in mechanics problems

Introduction to parallel computing. Parallelization using MPI. Parallel operations on vectors and matrices; linear systems solving and eigenvalue problems. Substructuring and domain decomposition. Parallelization in statistical simulation.

Debraj Ghosh

References:

- Karniadakis, G E and Kirby II, (2003) R M, Parallel Scientific Computing in C++ and MPI, Cambridge.

Pre-requisites:

- Programming experience using one of the languages among C/C++/Fortran. Familiarity with Linux/Unix.

CE 299 (JAN) 0:22

Project

The project work is aimed at training the students to analyze independently problems in geotechnical engineering, water resources engineering, structural engineering and transportation and infrastructural engineering. The nature of the project could be analytical, computational, experimental, or a combination of the three. The project report is expected to show clarity of thought and expression, critical appreciation of the existing literature, and analytical, computational, experimental aptitudes of the student.

Debraj Ghosh

Department of Chemical Engineering

Courses in the Department (2019)

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 DNA Nanotechnology
CH 299	0:32	Dissertation Project (M Tech)			

The detailed content of 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	Department Requirements
M Tech Programme, duration 2 years	64	Course work of 32 credits includes 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, and a 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	CH 201 to 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 201 (AUG) 3:0

Engineering Mathematics

Linear algebraic equations, linear operators, existence and uniqueness of solutions. Vector and function spaces, metric and normed spaces. Similarity transformations and canonical forms of matrices, application to linear ordinary differential equations. Eigenvalue problems, eigenvalues and eigenvectors/eigenfunctions. Adjoint and self-adjoint operators, Sturm-Liouville theory. Partial differential equations and their classification, initial and boundary value problems, solution by separation of variables, similarity solutions. Series solutions of linear ODEs. Elementary perturbation theory.

Prabhu R Nott

References:

- Linear Algebra and its Applications,Gilbert Strang,Thompson (Indian edition).
- Mathematical Methods for Physicists,J. B. Arfken and H. J. Weber (7th edition, Indian reprint, 2017).
- Mathematical Methods in Chemical Engineering, S. Pushpavanam, Prentice-Hall India (2005).
- Advanced Mathematical Methods for Scientists and Engineers, C. M. Bender and S. A. Orszag, McGraw-Hill/Springer-Verlag (2nd Indian reprint, 2010).

Pre-requisites:

- A basic course in Engineering or Applied Mathematics, including linear algebra, ordinary and partial differential equations.
- UG students must seek approval of instructor prior to registering for the course.

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

References:

- 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 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

References:

- 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 204 (AUG) 3:0

Thermodynamics

Classical thermodynamics: first and second laws, Legendre transforms, properties of pure substances and mixtures, equilibrium and stability, phase rule, phase diagrams, and equations of state, calculation of VLE and LLE, reaction equilibria, introduction to statistical thermodynamics.

Sudeep Punnathanam

References:

- Tester,J. W.,and Modell, M., Thermodynamics and its Applications

CH 206 (AUG) 1:0

Seminar Course

The course aims to help students in preparing, presenting and participating in seminars. The students will give seminars on topics chosen in consultation with the faculty.

Kesava Rao K

Pre-requisites:

- Open only to the Students from the Chemical Engineering Department

CH 235 (AUG) 3:0

Modeling in Chemical Enginereing

Modelling of a large variety of example systems to understand modelling of physical processes, four stages of model development; lumped parameter models; rate controlling step in series-parallel resistances; models for batch and continuous systems; distributed parameter n-d models; steady state, unsteady state, and pseudo-steady state models; homogeneous and pseudo homogeneous models; population balance models for birth and death of particles, bubbles, drops, cells, polymers, and residence time distribution; master equation for reversible and irreversible processes stochastic processes: predator - prey model; dispersion of pollutants downstream; moving control volume based models; element models; unit models, and kinetic Monte-Carlo simulations for stochastic systems.

Sanjeev Kumar Gupta

References:

- Lecture notes

CH 248 (AUG) 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

References:

- Philip Nelson, Biological Physics: Energy, Information, Life, W. H. Freeman, 2007
- Edda Klipp, Wolfram Liebermeister, Christoph Wierling, Axel Kowald, Hans Lehrach, Ralf Herwig, 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 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

References:

- Ming, D., Glasser, D., Hildebrandt

CH 207 (JAN) 1:0

Applied statistics and design of experiments

Overview of statistics; sample spaces and events; discrete and continuous random variables and probability distributions; sample mean and variance; point and interval estimates of the sample mean; tests of hypotheses; confidence intervals for the difference in the means of two samples; linear regression; introduction to designed experiments; analysis of variance; factorial experiments

Venugopal S

References:

- Montgomery, D.C. and Runger, R.C., Applied Statistics and Probability for Engineers, 6th ed., Wiley, Singapore (2014)
- Montgomery, D.C., Design and Analysis of Experiments, Wiley, 8th ed., Singapore (2013).
- Current literature

CH 234 (JAN) 3:0

Rheology of Complex Fluids and Particulate Materials

Introduction to the kinematics and rheology of complex fluids: Polymeric fluids, Suspensions, Pastes, and 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

References:

- 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.
- Russel, W. B., Saville, D. A. and Schowalter, W. R., Colloidal Dispersions,, 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

Sanjeev Kumar Gupta

References:

- 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 (book) given by instructor.

CH 247 (JAN) 3:0

Introduction to Molecular Simulations

Introduction to molecular dynamics; conservation laws; integration schemes: verlet, velocity verlet, leap-frog; constraint dynamics; extended Lagrangian dynamics; Thermostats and barostats; introduction to Monte Carlo techniques; Metropolis algorithm; NVT, NPT and GCMC simulations; estimation of pressure, chemical potential, radial distribution function, auto-correlation function, Ewald summation; umbrella sampling; Gibbs Ensemble technique; configuration bias technique, free energy estimation using thermodynamic integration

Ganapathy Ayappa, Sudeep Punnathanam

References:

- M. P. Allen and D. J. Tildesley, Computer simulation of Liquids, Oxford University Press, New York, 1987
- D. Frenkel and B. Smit, Understanding Molecular Simulation: From Algorithms to Applications, 2nd Ed., Academic Press, San Diego, 2002

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 be theoretical, experimental, or a combination of the two. 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, experimental or design skills, and new significant findings in the chosen area.

Venugopal S

Dept of Mechanical Engineering

M Tech Programme
Duration: 2 years
64 credits

Hard Core: 1 credit

ME 297 1:0 Seminar Course

Soft Core: (Any 4 out 5) 12 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

Maths requirement: 3 credits

ME 261 3:0 Engineering Mathematics

OR

Any other equivalent course recommended by the department

Project: 27 Credits

ME 299 0:27 Dissertation Project

Electives: 21 credits

The balance of 21 credits required to make up a minimum of 64 credits to complete the M.Tech Program.

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.

Jaywant H Arakeri, Ratnesh K Shukla

Pre-requisites:
- Kundu,P.K.,and Cohen,I.M.,Fluid Mechanics

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

References:
- 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 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, Koushik Viswanathan

Pre-requisites:
- Raghavan,V.,Materials Science and Engineers,Prentice Hall,1979. Davidge

ME 240 (AUG) 3:0

Dynamics and Control of Mechanical Systems

Representation of translation and rotation of rigid bodies, degrees of freedom and generalized coordinates, motion of a rigid body and multi-body systems, Lagrangian and equations of motion, small vibrations, computer generation and solution of equations of motion, review of feedback control, PID control, root locus, Bode diagrams, state space method, control system design and computer simulation.

Ashitava Ghosal, Jayanth G R

References:
- Greenwood,D.T.,Principles of Dynamics,Second Edn.,Prentice Hall

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.

Chandrashekhar S Jog

Pre-requisites:

- 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.

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

References:

- Malvern,L.E.,Introduction to the Mechanics of a continuous medium,Prentice Hall,1969. Gurtin

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-requisites:

- 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 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.

Yogendra Simha K R, Bobji M S

Pre-requisites:
- Halling,J. (ed.),Principles of Tribology,Macmillan,1975. Seireg

ME 259 (AUG) 3:0

Nonlinear Finite Element Methods

Introduction to structural nonlinearities, Newton-Raphson procedure to solve nonlinear equilibrium equations, finite element procedures for 1-D plasticity and visco-plasticity. Return mapping algorithm. Continuum plasticity theory. Stress updated procedures. Treatment of nearly-incompressible deformation. Fundamentals of finite deformation mechanics-kinematics, stress measures, balance laws, objectivity principle, virtual work principle. Finite element procedure for nonlinear elasticity. Lagrangian and spatial formulations. Finite element modeling of contact problems. Finite element programming.

Narasimhan R

References:
- Bathe, K.J., Finite Element Procedures, Prentice Hall of India, New Delhi 1997.
- Zienkiewicz, O.C., and Taylor, R.L., The Finite Element Method, Vols. I and II, McGraw Hill, 1991.
- Belytshko, T., Liu, W.K., and Moran, B., Nonlinear Finite Elements for Continua and Structures, Wiley, 2000.
- Simo, J.C. and Hughes, T.J.R., Computational Inelasticity, Springer, 1998.

Pre-requisites:
- ME257 or equivalent course.

Co-requisites:
- Student should have working knowledge of Fortran programming

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-requisites:
- ME 256. Background in finite element analysis is preferred.,. Bendsoe,M.P.,and Sigmund,O.

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.

Venkata R Sonti, Gaurav Tomar, Koushik Viswanathan

Pre-requisites:
- Kryyzig E,Advanced Engineering Mathematics,C.R. W ylie,Advanced Engineering Mathematics,M.D. Greenberg

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

Pramod Kumar, Susmita Dash

Pre-requisites:
- “Fundamentals of Classical Thermodynamics”,by G. Van Wylen,R. Sonntag and C. Borgnakke
- “Fundamentals of Engineering Thermodynamics”,by Moran and Shapiro
- “Advanced Thermodynamics for Engineers” by Kenneth Wark,Fluid Flow: A First Course in Fluid Mechanics

ME 285 (AUG) 3:0

Turbomachine Theory

Introduction to turbo-machines, mixing losses, review of vorticity, profile changes in contracting and expanding ducts. Brief review of diffusers, rotating co-ordinate system, total enthalpy, rothalpy, Euler turbine equation, velocity triangles. Specific speed and Cordier diagram, cascade aerodynamics. Elemental compressor stage, reaction work and flow coefficients. Equations of motion in axisymmetric flow, simple and extended radial equilibrium. Elemental axial turbine stage, radial and mixed flow machines, work done by Coriolis forces and by aerofoil action, the centrifugal compressor, vaned and vaneless diffusers.

Raghuraman N Govardhan

References:
- Sabersky,R.H.,and Acosta,A.,Fluid Flow: A First Course in Fluid Mechanics

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

References:
- Kreith,F.,and Kreider,J.F.,Principles of Solar Thermal Engineering

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.

Susmita Dash

Pre-requisites:
- Faculty Coordinator

ME 244 (JAN) 3:0

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

Pre-requisites:
- 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 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

References:
- Ghosal, A., Robotics: Fundamental Concepts and Analysis,,Oxford University Press, 2006,Notes and recent research papers.

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

References:
- 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

References:

- 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 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-requisites:

- a full course in lumped system vibrations,Werner Soedel ,Vibrations of plates and shells,S.S. Rao Vibrations of continuous systems

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

References:

- 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 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

References:

- 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

References:

- Israelachvili,J.N.,Intermolecular and Surface Forces,Elsevier Publishing Company,2003. Meyer

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.

Saptarshi Basu, Pramod Kumar

Pre-requisites:

- 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.

Ratnesh K Shukla

Pre-requisites:

- 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 283 (JAN) 3:0

Two Phase Flows and Boiling Heat Transfer

Characterization of two phase flow patterns (bubbly, slug, annular, mist, stratified, etc), homogeneous and heterogeneous flow models, suspension of particles in fluids, particulate fluidization, Bubble dynamics, Rayleigh-Plesset Equation, Boiling and Condensation Heat Transfer, Homogeneous and heterogeneous nucleation, Hydrodynamic stability of stratified fluids, molecular theory of surface tension, contact line dynamics, dewetting pathways.

Gaurav Tomar, Susmita Dash

References:

- Graham B Wallis, “One dimensional two phase flow”, McGraw Hill, 1969
- R T Knapp, J W Daily, F G Hammit, “Cavitation”, McGraw Hill, 1970
- R Clift, J R Grace and M E Weber, “Bubbles, drops and particles”, Dover, 1978
- P de Gennes, F Brochard-Wyart and D Quéré, “Capillarity and wetting phenomena”, Springer, 2004
- V P Carey, â€œLiquid-Vapor Phase-Change Phenomenaâ€•, Hemisphere Pub. Corp., 1992

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

References:

- 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 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

References:

- 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 290 (JAN) 3:0

Mechanics of slender elastic structures

Ramsharan Rangarajan

ME 291 (JAN) 3:0

Analysis of Manufacturing Processes

This course will provide a graduate-level introduction to manufacturing processes, from processing raw stock material to the final finished product. The emphasis will be on performing simple analyses to obtain quantitative estimates for process parameters (e.g., forces, pressures, energy) and product properties (e.g., residual strains, shape tolerances). Processes will be discussed and analysed following a broad classification and accompanied by in-class or lab demonstrations when possible. At the end of the course, the students will undertake a case study, where they will pick a product and make decisions, with relevant analysis, on the manufacturing process for each major sub-component.

Koushik Viswanathan

References:

- J. A. Schey (1987). Introduction to Manufacturing Processes. McGraw-Hill, NY.
- G. Dieter (1976). Mechanical Metallurgy. McGraw-Hill, NY.
- W. F. Hosford and R. M. Caddell (2011). Metal Forming: Mechanics and Metallurgy. Cambridge University Press
- L. Edwards and M. Endean (1990). Manufacturing with Materials. Butterworth-Heinemann, UK.

ME 293 (JAN) 3:0

Fracture Mechanics

Yogendra Simha K R, Narasimhan R

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

References:

- 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 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-requisites:

- Consent of Instructor Tennekes H and Lumley J L,,A First Course in Turbulence, MIT 1972,Pope S.B., Turbulent Flows, Cambridge, 2000

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.

Department of Materials Engineering

The **Department of Materials Engineering** is dedicated to the advancement of education and research in metallurgy and materials engineering. The research interests of the Department encompass Advanced Materials including nano-and bio-materials, ceramics, polymers, Structure-property relationship in metallic and non-metallic materials in both crystalline and amorphous form and advanced composites, in addition to the core areas like Process Metallurgy, Extractive Metallurgy, Physical Metallurgy and Mechanical behavior of materials. The Department plays a major role in the Advanced Facility for Microscopy and Microanalysis.

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

References:

- 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 203 (AUG) 3:0

Materials Design and Selection

After an overview of microstructures, processing and properties in engineering materials, the students will focus on procedures for materials selection and design. The students will explore materials selection charts, and the course will involve case studies, projects as well as software packages for materials design and selection over a wide range of conditions

Atul H Chokshi

References:

- M.F. Ashby: Materials Selection in Mechanical Design, 3rd edition (2005).
- M.F. Ashby and D. Johnson: Materials and Design (2002).

MT 206 (AUG) 3:0

Texture and Grain Boundary Engineering

Concepts of texture in materials, their representation by pole figure and orientation distribution functions. Texture measurement by different techniques. Origin and development of texture during material processing stages: solidification, deformation, annealing, phase transformation, coating processes, and thin film deposition. Influence of texture on mechanical and physical properties. Texture control in aluminum industry, automotive grade and electrical steels, magnetic and electronic materials. Introduction to grain boundary engineering and its applications.

Satyam Suwas

References:

- M. Hatherly and W. B. Hutchinson, An Introduction to Texture in Metals (Monograph No. 5), The Institute of Metals, London
- V. Randle, and O. Engler, Introduction to Texture Analysis: Macrotexture, Microtexture and Orientation mapping, Gordon and Breach Science Publishers
- F. J. Humphreys and M. Hatherly, Recrystallization and Related Phenomenon, Pergamon Press
- P. E. J. Flewitt, R. K. Wild, Grain Boundaries

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. Defect chemistry and properties affected by point defects. Dislocation theory - continuum and atomistic. Dislocations in different lattices. 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

References:

- 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 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

References:

- 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, Natarajan K A

References:

- M.G. Fontana: Corrosion Engineering, 3rd Edition, McGraw-Hill, N.Y., 1978.
- Borenstein: Microbiologically Influenced Corrosion Handbook.

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

References:

- 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 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

References:

- 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 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, precipitation strengthening, dispersion strengthening. martensitic strengthening. Creep, fatigue and fracture.

Subodh Kumar

References:

- Thomas H. Courtney, Mechanical Behaviour of Materials, Waveland Press.
- George E. Dieter, Mechanical Metallurgy, McGraw-Hill Book Company.

MT 261 (AUG) 3:0

Organic Electronics

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

References:

- 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 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

Pre-requisites:

- 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 208 (JAN) 3:0

Diffusion in Solids

Aloke Paul

References:

- 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

References:

- 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 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

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 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

References:

- 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 250 (JAN) 3:0

Introduction to Materials Science and Engineering

Subodh Kumar

MT 252 (JAN) 3:0

Science of Materials Processing

Fundamentals of Materials Processing: Deformation processing. Fundamentals and applications of plasticity, yielding, flow instability, drawability, anisotropy. Temperature and strain rate dependence. Thermally activated deformation, dynamic recovery and recrystallization. Modeling of materials processing-processing maps. Applications of deformation processing. Casting and Joining, Powder processing.

Satish V Kailas, Satyam Suwas

References:

- W.A. Backofen: Deformation processing: Addision Wesley.
- R.W. Cahn and P. Haasan (Editors): Processing of Metals and Alloys: Materials Science and Technology series, Wiley VCH
- B.H. Amstead, P.F. Oswald. and M. Begeman: Manufacturing Processes, John Wiley, 1987.

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

References:

- Abhik N Choudhury,J. Campbell: Casting, Butterworth - Haneman, London, 1993,M.C. Flemings: Solidification Processing , McGraw Hill, 1974.

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

References:

- 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 258 (JAN) 3:0

Mechanical Behavior of Thin Films

Short description of various 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

References:

- Materials Science of Thin Films by M. Ohring, Academic Press, 1992.

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

References:

- 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 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

References:

- Ratner et al: Biomaterials science: An introduction to materials in medicine,Lecture notes,Literature

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.

Rajeev Ranjan

MT 220 (MAY) 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

MT 271 (MAY) 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

References:

- Ratner et al: Biomaterials science: An introduction to materials in medicine,Lecture notes,Literature

Centre for Product Design and Manufacturing

Centre for Product Design and Manufacturing (CPDM), established in 1998, is the design and manufacturing face of IISc, and is among the most research and technology intensive design and manufacturing schools in India.

CPDM is among very few schools in India that train students in developing and making systemically complex, technologically intensive, and socially impactful solutions that are functional, aesthetic, usable and sustainable. It is among the top design schools in the world that specialise in training development of hardware products and manufacturing systems.

CPDM pursues excellence in teaching, research and industry interaction in the areas of design and manufacturing. The two-year professional Masters MDes programme (in Product Design and Engineering) has been the flagship programme of the Centre for over two decades. From August 2019, CPDM initiated, along with twelve partnering departments at IISc, an MTech in Smart Manufacturing.

CPDM has two active research programmes. One is in advanced design and engineering, spanning Design Theory & Methodology, Product Lifecycle Management, Human Factors in Design, User Interface Design, Vehicle Design, Technology Integration, Sustainability etc., with major applications in Automotive, Aerospace and Biomedical sectors. The other is an interdisciplinary programme in advanced manufacturing, with the following research areas (see details in the departmental webpage on research programmes): new materials and processes, digital manufacturing, manufacturing supply chains, sustainable manufacturing, Industry 4.0, controls, autonomous systems and robotics, and policy and entrepreneurship in manufacturing.

VISION

Pursue excellence in education, research and practice in the areas of design and manufacturing so as to support development of systemically-complex, technologically-intensive and socially-impactful solutions that are functional, aesthetic, usable and sustainable.

MISSION

Develop professionals in designing products and manufacturing systems that are functional, aesthetic, usable and sustainable; Create leaders who can strengthen existing practice and develop new practice in the areas of design and manufacturing; Develop products and manufacturing systems that can significantly impact the society; Develop knowledge, including methods and tools, to inform and empower practice and education of design and manufacturing.

SALIENT POINTS ABOUT CPDM

1. Pursue excellence in education, research and industrial interaction in design and manufacturing.

2. 2-Year M.Des. programme to train students with undergraduate degrees in engineering or architecture to conceptualize and engineer products to satisfy societal needs considering

functional, aesthetic, ergonomic, materials, manufacturing, cost, sustainability and marketing aspects.

3. 2-year M.Tech. programme to train students, with undergraduate degrees in engineering, in the areas of smart manufacturing, with exposure to design, materials, processes, digital manufacturing, sensors and mechatronics, AI and analytics, and in operations, supply chains and entrepreneurship.

4. Research programme in advanced product design and engineering (MTech by Research and PhD) in a variety of research areas, to develop new knowledge as theories, methods or tools for better design and associated engineering.

5. Research programme in advanced manufacturing (MTech by Research and PhD) in a variety of research areas, to develop new knowledge as materials, processes, systems, methods or tools for (better) manufacturing.

M Des Programme

Product Design and Engineering

Duration 2 years

Core Courses: 36 credits to be completed from the from the following pool of courses

CourseCode	Credits	CourseName
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	2:1	New Product Development: Concepts and Tools
PD 211	2:1	Product Design
PD 212	2:1	Computer Aided Design
PD 215	2:1	Mechatronics
PD 216	2:1	Design of Automotive Systems
PD 217	2:1	CAE in Product Design
PD 218	2:1	New Product Development: Strategy and Practice
PD 221	2:1	Methodology for Design Research
PD 229	0:3	Computer Aided Product Design
PD 231	2:1	Applied Ergonomics
PD 232	2:1	Human Computer Interaction
PD 233	2:1	Design of Biomedical Devices and Systems
PD 234	2:1	Intelligent User Interface
PD 235	2:1	Mechanism Design
PD 236	2:1	Embodiment Design
PD 239	0:3	Design and Society

Project: 16 Credits. This is mandatory for all

CourseCode	Credits	CourseName
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.

M Tech Programme

Smart Manufacturing

Duration 2 years

Hardcore Courses: The following courses to be completed by all students (22 Credits)

CourseCode	Credits	CourseName
MN 201	3:0	Materials and Processes
MN 202	3:0	Digital Manufacturing
IN 221	3:0	Sensors and Transducers
PD 203	2:1	Creative Engineering Design
EO 238	3:1	Intelligent Agents
MG 261	3:0	Operations Management
MN 205	0:3	Maker's Projects

Softcore Courses: Min. 12 credits by taking 6 credits from each of the two baskets of courses to be completed by all students

Basket 1: Design, Materials, Manufacturing (at least 6 credits)

MN 203	3:0	Design for Additive Manufacturing
MN 204	3:0	Human Machine Interfaces for Manufacturing
ME 291	2:1	Analysis of Manufacturing Processes
ME 246	2:1	Introduction to Robotics
MT 252	2:1	Science of Materials Processing

Basket 2: Sensors, Systems, Analytics (at least 6 credits)

EO 259	3:1	Data Analytics
E3 257	2:1	Embedded System Design
P3 258	2:1	Design for Internet of Things
E0 268	3:1	Practical Data Science
PD 215	2:1	Mechatronics
MG 223	3:0	Applied Operations Research

Project: 28 Credits**.** This is mandatory for all

MN 208	0:28	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.

MN 201 (AUG) 3:0

Materials and Processes

Engineering materials: crystal structure and bonding, elastic and plastic deformation, strengthening, fatigue, fracture, creep, wear Design considerations: bending, compression, tension, shapes and sections, multiple constraints, ecological and sustainability Processes: Broad classification of processes - casting, forming, cutting and joining – with simple analyses

Atul H Chokshi, Satish V Kailas, Satyam Suwas, Koushik Viswanathan

References:

- Materials Selection in Mechanical Design, 4th edition, M.F. Ashby, Elsevier (2011)   Introduction to Manufacturing Processes, J. A. Schey, McGraw-Hill, NY (1987) CES EduPack software package for materials design and selection (2019)

MN 202 (AUG) 3:0

Digital Manufacturing

Product modelling, Process Modelling, Intelligent machines, Autonomous devices in manufacturing, Interoperability of digital models in manufacturing, computer aided inspection and verification, Digital Thread and applications of digital models in maintenance and operations

Ashitava Ghosal, Gurumoorthy B, Dibakar Sen

Pre-requisites:

- Undergraduate-level mathematics, exposure to manufacturing processes, familiarity with CAD and computational tools such as SolidWorks, Matlab.

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

References:

- 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

References:

- 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

References:

- 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 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

References:

- 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

References:

- 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 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

References:

- (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 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

References:

- 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 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 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

References:

- Sanders and McCormick,Human Factors in Engineering and Design,Seventh Edn,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

References:

- 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

References:

- 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

MN 203 (JAN) 3:0

Design for Additive Manufacturing

Geometry processing pipeline in AM, considerations of shape representation – smooth vs. discrete; material choices in the design for additive manufacturing; material representation for AM Process planning; manufacturability constraints – design to minimize supports; Adapting extant designs for AM; Design Principles - Unitisation of structures; Basics of finite element analysis in the context of structural design for additive manufacturing; overview of size, shape, and topology optimization methods for structures; sensitivity analysis; lattice structures; hierarchy and economy; Standards

Gurumoorthy B, Ananthasuresh G K

Pre-requisites:

- Undergraduate-level mathematics, familiarity with CAD and computational tools such as SolidWorks, Rhino and Matlab.

MN 204 (JAN) 3:0

Human Machine Interaction for Manufacturing

Cognitive Psychology: Basic principles visual and auditory perception, top down and bottom up processing of visual and acoustic signal, memory structure, sensory, short term, long term memory, classification of error, memory retrieval process, rapid aiming movement, Fitts' Law, Implication in interaction design, User Modelling Introduction to Ergonomics, anthropometry and biomechanics, sensory capability and display design, display-control compatibility, spatial arrangements and interaction, manual and VR interactions, human error causes and mitigation. Ergonomic Principles: Usability Evaluation – Different methods of usability evaluation, Heuristics evaluation, Cognitive Walkthrough, Think Aloud Protocol, Cognitive Dimension of Notation, Simulation, User Trial Design, Statistical Hypothesis Testing, t-test, ANOVA AR/VR/Haptics Technologies: History of AR/VR, Difference among AR/VR/MR, Basics of Image Processing, Filtering, Edge and shape detection, Optics of VR headsets, Developing interactive AR/VR applications. Intelligent User Interfaces: Basics of AI, state space search algorithms, Bayesian Inference, Differences among Supervised, Unsupervised and Reinforcement Learning, Robotic path planning using Informed Search Algorithm (A*) and Markov Decision Process, Case studies on developing Intelligent User Interface Interactive Technologies-Eye tracking, Gesture recognition, haptic system, Wearable devices Manufacturing Case Studies UI/UX development: Training on developing UI and event driven programming using MS Visual Studio and Android, Interfacing with Arudino circuits.

Dibakar Sen, Pradipta Biswas

References:

- • 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, Morgan Kaufmann • Field A. Discovering Statistics Using SPSS, SAGE Publications Ltd., 2009. • The Wiley Handbook of Human Computer Interaction Set, John Wiley & Sons Inc, ISBN: 9781118976135, 1118976134 • Donald A. Normann, "Design of Everyday Things", 2013, Basic Books. ISBN-10 9780465050659, ISBN-13 978-0465050659. • Sanders, M.M. & McCormick, E.J. (1993) Human Factors in Engineering & Design 7th ed., McGraw-Hill, NY. ISBN-10 007054901X, ISBN-13 978-0070549012. • 3. Ray E. Eberts, User Interface Design, 1994, Englewood Cliffs, NJ: Prentice-Hall ISBN 0-13-140328-1 • 4. Jeff Johnson, Designing with the Mind in Mind: Simple Guide to Understanding User Interface Design Rules, ISBN-13: 978-0123750303, ISBN-10: 012375030X

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

References:

- 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

References:

- 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

References:

- 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 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

References:

- 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

New Product Development: Strategy and Practice

industry best practices, business and competitive strategy, product strategy and product planning, business planning, platform-based product development, market selection, ideation to prototyping, strategic fit, industry project based experiential learning with prototype development and business planning deliverables.

Gurumoorthy B

References:

- Michael McGrath, Product Strategy for High Technology Companies, 2nd Edition
- Paul Trott, Innovation Management and New Product Development, 4th Edition
- Clayton Christensen, The Innovator's Dilemma, 2016 edition

Pre-requisites:

- PD209: New Product Development: Concepts and Tools

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

References:

- 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 234 (JAN) 2:1

Intelligent User Interface

Basics of Artificial Intelligence(heuristic and state space search,Bayes Ru

Pradipta Biswas

References:

- 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 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

References:

- 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 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

References:

- 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 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.

Dibakar Sen

Centre for Sustainable Technologies

ST 202 (AUG) 3:0

Energy Systems and Sustainability

Basics of energy resources and systems, renewable energy technologies, climate change and sustainability, climate change mitigation options and low carbon future, energy technologies, economics, policies and programmes. Case studies on renewable energy projects

Dasappa S, Balachandra P

References:

- M. M. El-Wakil, Power Plant Technology, McGraw Hill.1984,Aldo Vieira Da Rosa, Fundamentals of Renewable Energy Processes , Elsevier, 2009.,Boyle, G., Everett, B. and Ramage, J., Energy Systems and Sustainability: Power for a Sustainable Future, Oxford University,Press, Oxford, UK, 2003. Cassidy, E., and Grossman, P., Introduction to Energy Resources, Cambridge University Press, 1998,IPCC, Renewable Energy Sources and Climate Change Mitigation - Special Report of the Intergovernmental Panel on Climate Change (IPCC), Cambridge University Press, New York, 2012, http://srren.ipcc-wg3.de/report/IPCC_SRREN_Full_Report.pdf

ST 204 (AUG) 1:1

Sustainable Energy and Environment lab

Energy conversion technologies, building comfort studies, water quality, building technologies

Venkatarama Reddy B V, Dasappa S, Monto Mani

Pre-requisites:

- Current literature.

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

References:

- Lillesand, T.M., and Kiefer, R.W., Remote Sensing and Image Interpretation, John Wiley & Sons, Inc., New York. Cambell, J.B., Introduction to Remote Sensing, Taylor and Francis. Jensen, J.R., Introductory Digital Image Processing: A Remote Sensing Perspective, Prentice Hall, New Jersey. Burrough, P.A., Principles of Geographical Information System for Land Resource Assessment, Oxford University Press.

Pre-requisites:

- NA

ST 214 (AUG) 3:0

Mathematical Analysis of Experimental Data

Design of Experiments, Data types and data gathering tools. Errors, systematic & random errors, methods to minimize them, and account for them. Measurement variability. Instrument calibration and corrections at different scales. Significant figures. Uncertainty analysis and curve fitting; Data analysis of data distribution, normal, Chi-squared and t-distribution, confidence interval and hypothesis testing. Design of experiments: replication, randomization, blocking and controls. ANOVA, Single factor experiments, randomized blocks, Latin square designs, factorial and fractional factorial designs. Simple and multiple linear regressions. Mathematical analysis of experimental data from problems in fluid flow, heat transfer and combustion.

Dasappa S, Lakshminarayana Rao M P

References:

- Douglas C. Montgomery, Design and Analysis of Experiments (2012), John Wiley and Sons, Inc.
- 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.

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

References:

- 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 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

References:

- DixonS.L and HallC.A, Fluid Mechanics and Thermo Dynamics of Turbomachinery, 6th Edition,Elsevier,publication 2010,
- Neschleba M, Hydraulic turbines-Their design and equipment , Atria Prage,1957,
- StepanoffA.J,Centrifugal and Axial Flow Pumps,JohnWiley & Sons,Inc.,1957,
- Horlock J.H,Axial Flow Compressors and Axial Flow Turbines,Fluid Mechanics and Thermodynamics,Butterworths,1958,
- Watson N and JanotaM.S, Turbocharging the Internal Combustion Engine ,The Macmillan Press,1982
- 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 201 (AUG) 2:1

Introduction to Earth System Science

Role of topography and geology during interaction of Earth system processes; composition of Lithosphere, Atmosphere, Hydrosphere and Biosphere; Earth surface processes and its effect on earth systems, earth as a dynamic planet; 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; Geochemical evidences documenting origin of life; extinction events, biosphere on land and ocean, Great oxygenation Event (GOE);Paleobiology; Microfossils; Indian climate present day and past; Global paleoclimatic record; Palaeo-monsoon record and the role of tectonics and green house forcing. Practical: Project on spatial and temporal evolution of earth system

Prosenjit Ghosh

References:

- Merrits, D., Dewet, A., and Menking, K., Environmental Geology: An Earth System Science Approach, 1998; Freeman, W.H.,
- Jacobson, M.C., Charlson, R.J., Rodhe, H., and Orians, G.H., Earth System Science, Academic Press, 2000; Merrits, D.,
- Dewet, A., and Menking, K., Environmental Geology: An Earth System Science Approach, 1998

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

References:

- 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 203 (AUG) 3:0

Introduction to Petrology

Theory: Rock forming minerals, textures of Igneous, metamorphic and sedimentary rocks, microtextures 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

References:

- Vernon R.H., A practical guide to Rock Microstructure, Cambridge University Press, 2004.

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

References:

- Charles H. Langmuir and Wally Broecker, How to build a habitable planet, Revised and expanded edition, Princeton University Press, 2012;
- A. P. Dickin, Radiogenic Isotope Geology, Cambridge University Press, 1995;
- John D. Winter, Principles of Igneous and Metamorphic Petrology, 2nd edition, Pearson Prentice Hall, 2010,

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

References:

- Riley, K.F., Hobson, M.P., and Bence, S.J., Mathematical methods for physics and engineering, Cambridge University Press, 2006.
- Panton, R.L., Incompressible flows, John Wiley & Sons, 2006
- Albarede, F., Introduction to geochemical modelling, Cambridge University Press, 1996
- Lecture notes

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

References:

- Schubert, G., Turcotte, D., and Olson, P., Mantle convection in the earth and planets, Cambridge University Press, 2001
- Turcotte, D., and Schubert, G., Geodynamics. Cambridge University Press, 2nd edition, 2001
- Fowler, C.M.R., The Solid Earth: An Introduction to Global Geophysics, Cambridge University Press, 2005.

ES 216 (AUG) 3:0

Advanced Chemical Oceanography

This is a course designed to delve in to the application of chemical oceanography, especially that of isotope tracers, to understand the long-term evolution of seawater and climate. The topics covered in the course will broadly include the: (1) the long-term evolution of seawater chemistry from the perspective of strontium, magnesium, osmium, and lithium isotopes; (2) changes in magnesium to calcium ratio of seawater over time; (3) boron isotopes and their application in pH reconstruction; (4) seawater carbonate chemistry – what controls the pH and alkalinity of seawater; (5) proxies and their application in paleoceanography.

Sambuddha Misra

References:

- Tracers in the Sea – Broecker and Peng, LDEO Press, 1983
- CO2 in Seawater – Zeebe and Wolf-Gladrow, Elsevier Oceanography Series, 2003
- Isotope Geochemistry – William White, Wiley Blackwell, 2015

ES 401 (AUG) 3:0

Natural Hazards and Their Mitigation

Kusala Rajendran

References:

-
- C.M.R.
- The solid earth: An Introduction to Global Geophysics
- Cambridge University Press
- 2005.

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

References:

- Alan P. Dickin,Radiogenic Isotope Geology,Cambridge University Press,1995,Gunter Faure and Teresa M. Mensing

ES 214 (MAY) 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

References:

- Grastein,Ogg and Schmitz,The Geologic Time Scale 2012 2-Volume Set,1st Edition,ISBN: 9780444594488

Division of Interdisciplinary Research

Preface:

The Division of Interdisciplinary Research consists of the Centre for Biosystems Science & Engineering, Department of Computational and Data Sciences, Centre for Society and Polity, Interdisciplinary Centre for Energy Research, Interdisciplinary Centre for Water Research, Centre for Nano Science and Engineering, Centre for Infrastructure, Centre for 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
MG	Management Studies
MS	Interdisciplinary Mathematical Sciences
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

Chair

Division of Interdisciplinary Research

INTERDISCIPLINARY PROGRAM - BioSystems Science and Engg

Educating a new breed of young scientists at the biology-engineering interface is the primary goal of the Interdisciplinary PhD Programme in BSSE. It is hoped that the students in this programme are at equal ease with a core area in biology and a core area in engineering.

Core Courses: 9 Credits

BE 203	0:1	Bioengineering practicum 1
BE 204	0:1	Bioengineering practicum 2
BE 207	3:0	Mathematical Methods for Bioengineers
BE 213	2:0	Fundamentals of Bioengineering 1
BE 214	2:0	Fundamentals of Bioengineering 2

Soft core (for students from engineering background who have not taken Biology after school)

BE 206	3:0	Biology for Engineers

Electives offered by department

BE 209	1:0	Digital Epidemiology
BE 210	3:0	Drug Delivery
BE 211	3:0	Cell Mechanics
BE 212	1:0	Research Communications

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 cover the following topics: 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 how cells form tissues will be covered, which includes lectures on classification of tissues. The concepts covered here will aid in the skill development required to study diverse problems in bioengineering.

Siddharth Jhunjhunwala, Vaishnavi Ananthanarayanan

References:

- Biology: Concepts and Connections, Third Edition. Campbell, Mitchell and Reece.
- Molecular Biology of the Cell, Fourth Edition. B. Alberts, A. Johnson, J. Lewis, M. Raff, K. Roberts and P. Walter

BE 209 (AUG) 1:0

Digital Epidemiology

Epidemiology is the study of health and disease in populations. Google's Flu Trends, Flowminder, Healthmap, Biodiaspora are several examples of digital epidemiology already in play. Engineered systems that are built from and depend upon, the seamless integration of computational algorithms and physical components is how National Science Foundation defines the field of cyber physical systems (CPS). Digital Epidemiology can be viewed as a health care application of CPS. The foundations of CPS includes a focus on the modeling of dynamic systems with attention to integrating computing, communication and control in uncertain and heterogeneous environments. Modeling paradigms include linear and non-linear, stochastic, discrete-event and hybrid models that are analyzed by methods of optimization, probability theory and dynamic programming. The purpose of this course is to introduce this emerging discipline of digital epidemiology to students at IISc. This offering of the course will be limited to a class size of 20 students.

Ananthasuresh G K

References:

- Epidemiology, A Very Short Introduction, Rodolfo Saracci, Oxford University Press
- Statistical models in Epidemiology, D. Clayton and M. Hills, Oxford University Press

Pre-requisites:

- The only prerequisite for this course is a reasonable preparation in computational mathematics

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

References:

- Drug Delivery: Engineering Principles for Drug Therapy, W. Mark Saltzman, Oxford University Press, 2001
- Drug Delivery: Fundamentals and Applications, Anya M. Hillery and Kinam Park

BE 211 (AUG) 3:0

Cell Mechanics

This course will provide an in-depth understanding of mechanics of the cell including theory of cellular architecture, mechanical forces, deformations, and adhesions, leading up to force generation and interaction of cells with the external environment. Additionally, practical aspects, including measurement of cell mechanics using experimental techniques such as micropipette aspiration, single particle tracking and atomic force microscopy will be presented. The topics covered will culminate in broad applications of cell mechanics in physiology, cell biology and biophysics with the syllabus comprising cell shapes, biomaterials (soft filaments and sheets in cells), forces inside cells, random walks, movement in a viscous fluid, viscoelasticity (background, constitutive models and measurement in cells), complex filaments, rheology of cytoskeletal filaments, biomembranes (bilayers, micelles, vesicle formation), cell-cell and cell-matrix interactions, micropipette aspiration, single particle tracking, atomic force microscopy, applications of cell mechanics viz. cell division, migration, morphogenesis, cancer metastasis.

Vaishnavi Ananthanarayanan

References:

- David Boal, Mechanics of the Cell, Cambridge University Press (2012)
- Christopher R. Jacobs, Hayden Huang, Ronald Y. Kwon, Introduction to Cell Mechanics and Mechanobiology, Garland Science (2013)
- Ronald Kaunas, Assaf Zamal, Cell and Matix Mechanics, CRC Press (2014)
- Jonathon Howard, Mechanics of Motor Proteins and the Cytoskeleton, Sinauer Associates Inc. (2001)

Pre-requisites:

- Undergraduate level introduction to Biology
- Undergraduate level introduction to Biology

BE 213 (AUG) 2:0

Fundamentals of Bioengineering 1

This course covers essentials of systems biology and biosensors. It caters to those who want to get first exposure to the topics that lay the foundation for advanced courses in these two topics. Systems biology: Dynamical systems biology, Feedback loops in biological systems, Cellular decision-making and cell differentiation, Mathematical modeling and nonlinear dynamics of biochemical reactions and networks, cell-to-cell variability and stochasticity in biological networks. Biosensors: The recognition-transduction system in a biosensor, chemistries for detection of small molecules, proteins/polypeptides, and nucleic acids; electronic and optical signal detection; microfluidics and its applications in biosensing; fluid dynamics and chemical kinetics of microfluidic biosensors; introduction to point-of-care biosensing; systems engineering approach in designing sample-in-answer-out biosensors

Bhushan J Toley, Mohit Kumar Jolly

BE 203 (JAN) 0:1

Bioengineering Practicum 1

Rachit Agarwal

BE 204 (JAN) 0:2

Bioengineering Practicum 2

Rachit Agarwal

BE 207 (JAN) 3:0

Mathematical Methods for Bioengineers

Narendra M Dixit

BE 211 (JAN) 3:0

Cell Mechanics

Vaishnavi Ananthanarayanan

BE 212 (JAN) 1:0

Research Communication

The course aims to help you sharpen the communication skills required for a researcher.

Karthik Ramaswamy

References:

- JM Williams and GG Colomb (2012) Style: The Basics of Clarity and Grace. 4th Edn. Pearson Longman Press.
- SB Heard (2016) The Scientist's Guide to Writing: How to Write More Easily and Effectively Throughout Your Scientific Career. 1st Edn. Princeton University Press.
- GD Gopen and J Swan (1990) The Science of Scientific Writing. American Scientist. 78:550-558

BE 214 (JAN) 2:0

Fundamentals of Bioengineering 2

This course covers essentials of biomaterials and mechanics. It caters to those who want to get first exposure to the topics, which lays the foundation for advanced courses in these two topics. Biomaterials: Basics of polymer science, polymeric materials in the body; non-polymeric implantable materials; biological responses to implants; an introduction to drug delivery systems; principles of tissue engineering. Biomechanics: Rigid-body mechanics in the context of motion of limbs and locomotion; elastic-body mechanics of living matter; stress, strain, constitutive relationships, and balance laws; introduction to viscoelasticity; a brief overview of mechanics of muscles.

Ananthasuresh G K, Siddharth Jhunjhunwala

References:

- Biomaterials Science, B.D. Ratner et. al., 3rd Edition, Academic Press, 2012.
- A Textbook of Biomechanics, S. Pal, Viva Books, New Delhi, India, 2009
- An Introduction to Biomechanics, J. D. Humphrey and S. L. O'Rourke, Springer, 2015
- Viscoelastic Solids, R. S. Lakes, CRC Press, Boca Raton, FL, USA, 1998
- Muscles, Reflexes, and Locomotion, Princeton University Press, Princeton, NJ, USA, 1984

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

ER 203 (AUG) 3:1

Renewable Energy sources, Grid Integration and Distribution

Overview of primary and renewable energy sources installed capacity and projected growth. Device physics: Crystal structure, Energy band diagram, Charge carriers, Heterojunctions, Diode characteristics. Photovoltaic device structures, Device fabrication techniques, PV characterization techniques, Reliability and end of life analysis. Introduction to wind energy and micro-hydro, power - speed characteristics, operating point, sub-synchronous and super-synchronous operation of alternators, DFIG, integration to the grid. MPPT for Renewable sources, battery charging, estimation and sizing of PV system for various applications Recent advances in power transmission, Distribution, Components of HV transmission systems, Insulation coordination, Comparison of Air Insulated, Hybrid and Gas Insulated Substations, Earthing and safety measures, electric and magnetic fields. Laboratory experiments 1. Study of the voltage and current of the solar cells 2. Study of the voltage and current in series and parallel combinations 3. Study of both current and voltage characteristics and power curve to find the maximum power point and efficiency of solar cell 4. To calculate the efficiency of solar cell 5. Study of observation of single axis solar tracking in time mode 6. Study of observations of single axis solar tracking in auto mode 7. Study of the operation of dual axis solar tracking system in manual mode 8. To show the effect of variation in tilt angle on PV module power 9. To demonstrate the effect of shading on module output power 10. To demonstrate the working of a diode as a Bypass diode and blocking diode 11. Technical visit to Solar field & substation

Umanand L, Subba Reddy Basappa, Praveen C Ramamurthy

References:

- Semiconductor Physics and Devices Basic Principles Donald A. Neamen, McGraw Hill publications. IEEE transactions, Photovoltaic specialist conferences etc. Recent Journals and conference publications

ER 204 (AUG) 3:0

Energy and Environment

Basic Thermodynamics and Thermochemistry, Chemical equilibrium, Chemical kinetics, Pollutant formation in energy generation, Atmospheric Smog formation, Pollutant abatement techniques, Clean Coal technologies, Measurements and analysis of Emissions from devices using solid, liquid and gaseous fuels and their impact on climate and other aspects of the environment, Aerosols, Black carbon, Aerosol measurement techniques, Effect of aerosols on surface reaching solar radiation.

Dasappa S, Ravikrishna, R. V., Satheesh S K

References:

- Borman, G.L. and Ragland, K.W ., Combustion Engineering, McGraw-Hill International Editions, Mechanical engineering series,
- 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.
- Guide to Meteorological Measurements and Methods of Observation World Meteorological Organization Publication No. 8,,7th Edition, W MO, Geneva radiative transfer, the role of radiation in climate.
- Papers from Current literature

ER 206 (AUG) 3:0

Transport Phenomena in Energy Systems

Heat Transfer: Conduction - 1-Dim., Transient, Rectangular Coord.,Cylindrical Coord. Radiation - Simple Concepts Convection - Laminar Flow, Turbulent Flow, Use of Heat Transfer Correlation's, Development of Heat Transfer Correlation's Fluid Mech.: Conservation equations, Reynold's Transport theorem, viscous fluid flow Mass Transfer: Ficks law, simple diffusion problems, mass transfer correlation's.

Saptarshi Basu, Pramod Kumar

Computational and Data Sciences

M Tech Programme
Duration: 2 years
64 Credits

Course structure:

Hard Core : 14 credits (incl. Research Methods: 1 credit soft skills course)
Soft Core : 10 credits minimum (at least three courses)
Dissertation : 28 credits
Electives :12 credits (Students may credit CDS electives/soft core or other department courses)
Total: 64 credits

Hard Core Courses (14 credits): All are compulsory

DS 221 AUG 3:1 Introduction to Scalable Systems
DS 284 AUG 2:1 Numerical Linear Algebra
DS 288 AUG 3:0 Numerical Methods
DS 294 JAN 3:0 Data Analysis and Visualization
DS 200 AUG 0:1 Research Methods – SOFT SKILLS COURSE

Soft Core Courses (10 credits): Minimum three courses out of six below

DS 201 AUG 2:0 Bioinformatics
DS 211 AUG 3:0 Numerical Optimization
DS 256 JAN 3:1 Scalable Systems for Data Science
DS 289 JAN 3:1 Numerical Solution of Differential Equations
DS 290 AUG 3:0 Modelling and Simulation
DS 295 JAN 3:1 Parallel Programming

Dissertation Project**: DS 299 0:28 (0:4 Summer; 0:8 AUG; 0:16 JAN)**

The balance of credits to make up the minimum of 64 required for completing the programme (all at 200 level or higher).

DS 200 (AUG) 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.

Phaneendra Kumar Yalavarthy

Pre-requisites:
- Consent from Advisor,Basic knowledge of english,Basic comprehension skills

DS 201 (AUG) 2:0

Bioinformatics

Unix utilities, overview of various biological databases (Protein Data Bank, structural classification of proteins, genome database and Cambridge structural database for small molecules), introduction to protein structures, introduction to how to solve macromolecular structure using various biophysical methods, protein structure analysis, visualization of biological macro molecules, data mining techniques using protein sequences and structures. short sequence alignments, multiple sequence alignments, genome alignments, phylogenetic analysis, genome context-based methods, RNA and transcriptome analysis, mass spectrometry applications in proteome and metabolome analysis, molecular modeling, protein docking and dynamics simulation. Algorithms, scaling challenges and order of computing in big biological data.

Sekar K, Debnath Pal

References:
- C. Branden and J. Tooze (eds) Introduction to Protein Structure, Garland, 1991
- Mount, D.W., Bioinformatics: Sequence and Genome Analysis, Cold. Spring Harbor Laboratory Press, 2001.
- Baxevanis, A.D., and Ouellette, B.F.F. (Eds), Bioinformatics: A practical guide to the analysis of the genes and proteins, Wiley-Interscience, 1998

Pre-requisites:
- Undergraduate level familiarity in Physics, Chemistry and Maths.

DS 211 (AUG) 3:0

Numerical Optimization

Introduces numerical optimization with emphasis on convergence and numerical analysis of algorithms as well as applying them in problems of practical interest. Topics include: Methods for solving matrix problems and linear systems that arise in the context of optimization algorithms. Major algorithms in unconstrained optimization (e.g., modified Newton, quasi-Newton, steepest descent, nonlinear conjugate gradient, trust-region methods, line search methods), constrained optimization (e.g., simplex, barrier, penalty, sequential gradient, augmented Lagrangian, sequential linear constrained, interior point methods), derivative-free methods (e.g., simulated annealing, Bayesian optimization, Surrogate-assisted optimization), dynamic programming, and optimal control.

Deepak Subramani

Pre-requisites:
- Basic knowledge of Numerical Methods,Basic knowledge of Linear Algebra,Consent from Advisor

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

Pre-requisites:
- Basics of computer systems,Basic data structures and programming,Basic algorithms,Consent of instructor

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.

Venkatesh Babu R, Anirban Chakraborty

References:
- Richard Szeliski, Computer Vision: Algorithms and Applications, Springer 2010
- Forsyth, D.A., and Ponce, J., Computer Vision: A Modern Approach, Pearson Education, 2003.
- Current Literature

Pre-requisites:
- Basic knowledge of Image Processing, Probability

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

Pre-requisites:
- Basics of matrix algebra,Basic programming,Vectors and vector spaces

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.

Phaneendra Kumar Yalavarthy

Pre-requisites:
- Consent from Advisor,Good knowledge of basic mathematics,Basic programming skill,Basic knowledge of multivariate calculus and elementary real analysis

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

References:

- 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.

Pre-requisites:
- Basic course on numerical methods and consent of the instructor.

DS 291 (AUG) 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

Pre-requisites:
- Consent from Advisor,Good knowledge of numerical analysis,Basic programming skill

DS 323 (AUG) 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

References:

- 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.

Pre-requisites:

- Consent from Advisor,Good knowledge of finite element methods,C/C++.

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

Pre-requisites:

- Consent from Advisor,Basic course on operating systems,Basic programming skill

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

Pre-requisites:

- Data Structures and Algorithms,Strong programming experience preferably in Java,Courses like DS 221; DS 252; DS 222; or E0 251

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

Pre-requisites:
- Consent from Advisor,Basic knowledge of system theory,Good knowledge of basic mathematics

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, Anirban Chakraborty

References:
- Current Literature

Pre-requisites:
- Consent from Advisor,Basic knowledge of Computer Vision and Machine Learning,Proficiency in Python,C/C++

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.

Aditya Konduri

Pre-requisites:
- Consent from Advisors,Basic course on numerical methods,Good knowledge of basic mathematics

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.

Anirban Chakraborty

Pre-requisites:
- Consent from Advisors,Basic knowledge of numerical methods,Good knowledge of basic mathematics

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

Pre-requisites:
- Consent from Advisor,DS 221 Introduction to scalable systems,A graduate level course on algorithms,Fundamentals of MPI,OpenMP and GPU architectures

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.

Pre-requisites:
- Consent from Advisor,Literature review,Clear idea about the research project

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

References:

- Edward Ott, Chaos in Dynamical Systems, Camridge press, 2nd Edition, 2002.(or one of the many excellent books on dynamical systems)
- Van Leeuwen, Peter Jan, Cheng, Yuan, Reich, Sebastian, Nonlinear Data Assimilation, Springer Verlag, July 2015.
- Sebastian Reich, Colin Cotter, Probabilistic Forecasting and Bayesian Data Assimilation, Cambridge University Press, August 2015.
- Law, Kody, and Stuart, Andrew, and Zygalakis, Konstantinos, Data Assimilation, A Mathematical Introduction, Springer Texts in Applied Mathematics, September 2015.
- Särkkä, Simo. Bayesian filtering and smoothing. Cambridge University Press, 2013

Pre-requisites:

- Consent from Advisor,Good knowledge of basic mathematics,Basics of data science

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

Pre-requisites:

- Consent from Advisor,Basic knowledge of digital electronics,computer organization and design,Basic knowledge of computer architecture,data structures and algorithms

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

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

Pre-requisites:

- Lecture notes hands-on training manuals,Hands-on training manuals,Handouts on detailed process flows and device characterization schedule

NE 202 (AUG) 0:2

Micro AND Nano Fabrication

This course is designed to give training in device processing at the cleanroom facility in CeNSE. The first part of the course teaches students pre-defined modules. This requires students to attend a lab session/week. Specifics change but the module can be one or two of the following: i) p-n junction diode, ii) MOS capacitor iii) MEMS Cantilever iv) Microfluidic channel. The second half of the project which is ~2/3 of course length is a project that must be done in groups of 2-3. The project is expected to be a significant investment of time, that justifies the 0:2 credit weight. Places are limited. CeNSE students get priority.

Shankar Kumar Selvaraja, Sushobhan Avasthi

Co-requisites:

- NE203

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

References:

- Stephen A. Campbell, The Science and Engineering of Microelectronic Fabrication

- Sorab K. Gandhi, VLSI Fabrication Principles: Silicon and Gallium Arsenide
- Richard C. Jaeger, Introduction To Microelectronic Fabrication

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

References:

- Streetman and Banerjee,Solid State Electronic Devices,Prentice-Hall,-,-

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.

Ambarish Ghosh, Shankar Kumar Selvaraja

Pre-requisites:

- Bahaa Saleh and Malvin Teich, Fundamentals of Photonics, Wiley and Son (1991) Hecht E, Optics. Addison Wesley, 2001,-,-,-,-

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

References:

- Stephen Elliott, Physics and Chemistry of Solids John Wiley, 1998,S. M Lindsay, Introduction to Nanoscience, Oxford (2010)

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.

Saurabh Arun Chandorkar

References:

- 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 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

References:

- 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 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

References:

- 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 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

Pre-requisites:
- Lecture notes

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, Varun Raghunathan

Pre-requisites:
- 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 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

References:
- 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 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

Pre-requisites:

- 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

Pre-requisites:

- Handouts on detailed process flows and device characterization schedule,-,-

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

References:

- John A. Palesko and David H. Bernstein, Modeling MEMS and NEMS, Chapman and Hall/CRC,-,-

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

References:

- 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 299 (JAN) 0:27

Dissertation Project

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

References:

- 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 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

References:

- Anthony E. Siegman, Lasers, University Science Books (1986),OrazioSvelto, Principles of Lasers, Springer (2010),Miscellaneous Research Articles and Reviews.

NE 314 (JAN) 3:0

Semiconductor Opto-electronics and Photovoltaics

An advanced graduate level course, NE314 provides a detailed overview of various optoelectronic devices such as LEDs, photodetectors and solar cells. The focus is more on the device physics, though some material and fabrication issues are also discussed. The course is designed for students who have a background in semiconductor device physics. A basic device course, such as NE205, is a strongly suggested prerequisite.

Sushobhan Avasthi, Digbijoy N Nath

References:

- Solar Cells, Operating principles, Technology and System Applications, Martin A. Green, Prentice Hall.
- Semiconductor Physics: An Introduction, Karlheinz Seeger, Springer

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

Pre-requisites:

- 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,-,-

Department 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	Behavioural 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 Intellectual 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

References:

- 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's macroeconomic 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

References:

- 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

References:

- Luthans,F,Organizational Behaviour,McGraw-Hill,1988. Weiten

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

References:

- Douglas C. Montgomery & George C. Runger,Applied Statistics and Probability for Engineers,Wiley India Pvt. Ltd.,Fifth Edition,2014

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

Pre-requisites:

- 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.

Yadnyvalkya

References:

- Harold Koontz and Heinz Weihrich,Essentials of Management – An International Perspective,Tata McGraw Hill Education Pvt. Ltd.,New Delhi,8th Edition

MG 241 (AUG) 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

Pre-requisites:

- Phillip Kotler,Marketing Management - Analysis,Planning and Control,13th Edition,Prentice-Hall of India

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

References:

- 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.

MG 246 (AUG) 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

References:

- 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.

Pre-requisites:

- MG 241 Marketing Management

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

References:

- Stevenson,William,J.,Production/Operations Management. 6th Edition. Irwin/McGraw-Hill.,Krishnaswamy

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

References:

- 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 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

References:

- Thahaman,H.J.,Management of Technology,New Jersey: John Wiley & Sons,2005.

FL 141 (JAN) 3:0

Preliminary Course in Russian

Phonetics, speech patterns, tables, lexical and grammatical exercises and dialogues

Yadnyvalkya

References:

- I.S. Krishtofova and T.S. Gamzkova,Russian Language For All.,L. Muravyova,Verbs of Motion in Russian,Russian Language Publishers

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

References:
- DeCenzo and Robbins,Personnel and Human Resource Management,Prentice Hall,1988.,Werther and Davis

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

References:
- Michael H. Kutner,Christopher J. Nachtsheim,John Neter & William Li,Applied Linear Statistical Models,McGraw-Hill International Edition

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].

Mathirajan M

References:
- Anderson,Sweeny,and Williams,An Introduction to Management Science: Quantitative Approaches to Decision Making,11th Edition

MG 226 (JAN) 3:0

Advanced Analytics

Mukhopadhyay C

MG 251 (JAN) 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.

Shashi Jain

Pre-requisites:

- 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 258 (JAN) 3:0

Financial instruments and risk management strategies

Shashi Jain

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

References:

- 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 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

References:

- Weimer,D.L.,and Vining A.R.,Policy Analysis: concepts and practice,Prentice Hall

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

References:

- 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

INTERDISCIPLINARY PROGRAM - CYBER PHYSICAL SYSTEM

The Robert Bosch Centre for Cyber-Physical Systems (RBCCPS) @ IISc is a research and academic centre, under the Division of Interdisciplinary Research. The centre focuses on foundational and applied research to solve cutting edge problems in Robotics involving advanced machine learning techniques, Connected Autonomous Systems like drones and 5G-enabled autonomous vehicles, and Socio-Technical Systems like urban transportation systems and Smart Cities. The Centre faculty are drawn from various existing departments. The Centre runs an interdisciplinary PhD program in Cyber-Physical Systems and offers various short and semester long courses.

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, 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 (including recent advances in visual odometry based on deep learning) through a combination of lectures, associated hands-on lab assignments as well as individual and group projects.

Chiranjib Bhattacharyya

References:

- PROBABILISTIC ROBOTICS, Sebastian Thrun, Wolfram Burgard, D. Fox, MIT Press, 2005.
- COMPUTER VISION: ALGORITHMS AND APPLICATIONS, Richard Szeliski, Springer, 2010.
- MULTIPLE VIEW GEOMETRY IN COMPUTER VISION, Richard Hartley and Andrew Zisserman, Cambridge Press, 2003.

Prerequisites :

- (E2 202) or Probability and Statistics (E0 232) or its equivalent
- Linear Algebra and Applications (E0 219) or its equivalent

Co-Requisites :

- Basic knowledge of optimization methods, algorithm design, programming and machine learning will be assumed.