Scheme of Instruction

Academic Year 2020-21

Index

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 are allowed 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 M indicates the number of lecture credits and
N the 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 it has 2 lecture hours and one3-hour laboratory session each week, while a course with 3:0 credits indicates a course with 3 lecture hours and no laboratory session.

The Institute offers research-based doctoral programmesand Master'sprogrammes that are both course-based and research-based. Eachcourse-based Master'sprogramme 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. Students are assigned faculty advisors who will advise them in selecting and dropping courses, 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 Student InformationHandbook.

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. The grades 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 programmeshave to take a minimum number of credits as part of their Research Training Program (RTP). For PhD students in Science, the RTP consists of a minimum of 12 credits. For PhD students in Engineering who join with a Master's degree in Engineering, the RTP requirement is a minimum of 12 credits. For PhD students in Engineering who join with a Bachelor's degree in Engineering or a Master's degree in Science, the RTP consists of a minimum of 24 credits. Similar RTP requirements apply for students who upgrade or continue their registration from the Mastersprogrammes 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 as detailed in the Student Information Handbook.

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

25th September 2020

Raghuraman N. Govardhan
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 in fundamental and applied sciences, such as biology, chemistry, physics, medicine, agriculture and technology, 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 Program for students registering for research conferment's at the Institute. For individual requirements, the students are advised to approach the Departmental Curriculum Committee.

The Department of Biochemistry offers a program of study concentrating on a molecular approach towards understanding biological phenomena. The program 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, experimental and field based research in plant and animal ecology, evolution and behavior. The program of instruction consists of lectures, laboratory work, seminars and special assignments.

The Department of Microbiology and Cell Biology offers courses in microbiology, infectious diseases, cell biology, molecular biology, genetic engineering, RNA biology, developmental genetics, cancer biology and ageing and regeneration. 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, biophysical techniques, cellular neurophysiology and computational neuroscience.

The courses offered in the Department of Molecular Reproduction, Development and Genetics include those on signal transduction, gene expression and development, genetics and genomic medicine, molecular oncology, aging and regeneration.

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

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

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

Prof. Usha Vijayraghavan
Dean,
Division of Biological Sciences

Integrated PhD (Biological Sciences)

Course Work:

Core Courses: 14 credits (6 Core courses in Aug)

1.	DB201 (AUG) 2:0	Mathematics and Statistics for Biologists
2.	DB202 (AUG) 2:0	General Biology
3.	BC203 (AUG) 3:0	General Biochemistry
4.	MB201 (AUG) 2:0	BiophysicalChemistry
5.	MC203 (AUG)3:0	Essentials in Microbiology
6.	RD 201 (AUG)2:0/ DB204	Genetics

Projects: 18 Credits:

DB212	0:6	Project –I	JAN
DB225	0:6	Project –II	AUG
DB327	0:6	Project –III	JAN

Elective Courses: 32 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

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.

PurusharthRajyaguru, Sathees C. Raghavan, Patrick D Silva, Ganesh Nagaraju

References:

• StryerL.,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

DipshikhaChakravortty, Utpal Tatu

DB 212 (JAN) 0:6

Biological Science

DipshikhaChakravortty

DB 327 (JAN) 0:6

Biological Science

An independent research project tobe 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.

DipshikhaChakravortty

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.

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

Pre-requisites :
- Alberts et al.,Molecular Biology of the Cell,Thirdedition,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.

Nagasuma R Chandra, Narasimha Rao D, Utpal Tatu

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.

PurusharthRajyaguru, Sathees C. Raghavan, Patrick D Silva, Ganesh Nagaraju

Pre-requisites :
- StryerL.,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, Sandeep M Eswarappa, Sathees C. Raghavan

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

Centre for Ecological Sciences

The Center for Ecological Sciences has excellent facilities for theoretical, experimental and field based research in plant and animal ecology, evolution and behavior. The programme of instruction consists of lectures, laboratory work, seminars and special assignments.

EC 101 (AUG) 1:0

Process of Scientific Thinking

Approaches of scientific practice and research conduct. Historical perspective of various philosophies of science and the process of scientific thinking (e.g. deduction, induction and Inference by Best Explanation). Ethics in conducting, writing, and publishing science (including plagiarism), best practices for replicable research. How to read and review scientific literature critically.

Maria Thaker

References :
- Samir Okasha. 2016. Philosophy of Science: a very short introduction. Oxford University Press

Pre-requisites :
- Targeted for PhD and MSc students in the field of ecology and evolution. Interested students in other fields should email the instructor in advance.

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, predator-prey interactions.

Rohini Balakrishnan, Maria Thaker

References:
- Animal Behavior (Second Edition). Michael D. Breed, Janice Moore (2016) Elsevier
- Neuroethology – J. M. Camhi (1984) Sinauer Associates, Sunderland
- An Introduction to Behavioural ecology. J. R. Krebs, N. B. Davies and S. A. West (2012) Blackwell Press, Oxford University Press
- 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 305 (AUG) 2:1

Quantitative Ecology: Research Design and Inference

This course will focus on study design and statistical modelling in ecology. We will examine elements of effective study design, common pitfalls in study design and data collection, and the confrontation of ecological hypotheses with data using different statistical approaches and frameworks of inference. Throughout, we will examine concepts using examples from ecology, animal behaviour and evolution. The course will aim to provide proficiency to carry out various statistical techniques commonly used in ecology using the software R. The main topics that will be covered are: 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 :
- Gotelli NJ and Ellison AM (2013) A Primer of Ecological Statistics. Sinauer
- Zuur A, Ieno EN and GM Smith 2007 Analysing ecological data. Springer

Pre-requisites :
- As a single entry: A background in ecology, behaviour or evolution, either in the form of courses taken or projects completed, currently being carried out or currently being planned, or equivalent in ecology/behaviour/evolution

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.

VishweshaGuttal

References :
- Strogatz, Nonlinear Dynamics And Chaos: With Applications To Physics, Biology, Chemistry, And Engineering Westview Press 2014, 2nd edition, (ISBN: 978-0738204536)
- Nicholas Gotelli, A primer of Ecology, RedShelf, 2008, (ISBN: 9781605354088)
- McElreath and Boyd, Mathematical Models of Social Evolution: A guide for the perplexed, (ISBN: 9780226558271)

EC 202 (JAN) 2:0

Ecology: Pattern and Process

History of ecology; interactions between organisms and the environment; ecological niche; distribution of species and communities; basic population biology; interspecific interactions; community assembly; diversity, richness and abundance; ecosystem structure and function; species concepts; ecological and evolutionary processes (dispersal and diversification); island biogeography; meta-population biology; macroecology.

Umesh Srinivasan, Kartik Shanker

References :
- A.E. Magurran, Measuring Biological Diversity, Blackwell Publishing, 2004.
- J.H. Brown and M.V. Lomolino, Biogeography (Second Edition), Sinauer Associates, 1998
- Pianka, E.R. Evolutionary Ecology. Eric R. Pianka, e-book, 2011

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.

Kartik Sunagar, Praveen Karanth K

References :

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

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.

SumantaBagchi

References :

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

Pre-requisites :

- EC202

Molecular Biophysics Unit

Course Code	Name	Credits	Instructor	Time Slot
MB201	Introduction to Biophysical Chemistry	2:0	Prof. Raghavan Varadarajan varadar@iisc.ac.in	T, Th 11:00 AM - 12:00 PM
MB204	Molecular Spectroscopy and its Biological Applications	3:0	Prof. Siddhartha P Sarma, Dr. Mahavir Singh sidd@iisc.ac.in	M, W, F 9:00 AM - 10:00 AM
MB205	Introduction to X-Ray Crystallography	2:0	Dr. Aravind Penmatsa, Prof. Kaza Suguna penmatsa@iisc.ac.in	M, W, F 10:00 AM - 11:00 AM
MB206	Conformational and Structural aspects of Biopolymers	3:0	Prof. N Srinivasan, Dr. Anand Srivastava, Dr. Mahavir Singh ns@iisc.ac.in	M, W, F 11:00 AM - 12:00 PM
MB214	Neuronal Physiology and Plasticity	3:0	Prof. Rishikesh Narayanan rishi@iisc.ac.in	M, W 11:00 AM -12:30 PM
MB305	Biomolecular NMR Spectroscopy	3:0	Prof. Siddhartha P Sarma, Dr. Ashok Sekhar ashoksekhar@iisc.ac.in	M, W, F 2:00 PM - 3:00 PM

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.

Mahavir Singh, Siddhartha P Sarma

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.

Aravind Penmatsa, Kaza Suguna

Pre-requisites :
- Buerger,M.J.,ElementaryCrystallography,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.

Mahavir Singh, Anand Srivastava, Srinivasan N

Pre-requisites :
- Ramachandran,G.N.,andSasisekharan,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

Pre-requisites :
- Prerequisites: References: 1. "Foundations of Cellular Neurophysiology" by Daniel Johnston and Samuel Wu, MIT Press, 1995.
- 2. "Neuroscience" by Dale Purves, George J. Augustine, David Fitzpatrick, William C. Hall, Anthony-Samuel LaMantia, Richard D. Mooney, Michael L. Platt, Leonard E. White, Oxford University Press, 2017.
- 3. "The Hippocampus Book" by Per Andersen, Richard Morris, David Amaral, Tim Bliss and John O'Keefe. Oxford University Press, 2006.
- 4. "Dendrites" by Greg Stuart, Nelson Spruston and Michael Hausser. Oxford University Press, 2016. 5. "Synapses" by W. Maxwell Cowan, Thomas C. Südhof, Charles F. Stevens, The Johns Hopkins University Press, 2003. 6. "The synaptic organization of the brain" by Gordon Shepherd, Oxford University Press, 2004. 7. "Rhythms of the Brain" by GyorgyBuzsaki, 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.

Ashok Sekhar, Siddhartha P Sarma

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

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.

Amit Singh, Samay Ravindra Pande, DipshikhaChakravortty

References :

• (1) Stanier, R.V.,Adelberg E.A and Ingraham J.L., GENERAL MICROBIOLOGY, Macmillan Press, Fourth edition; (2) Westriech, G.A. and Lechmann M.D., MICROBIOLOGY, Macmillan Press, Fifth Edition; (3) Atlas R.M., MICROBIOLOGY: FUNDAMENTALS AND APPLICATIONS, Macmillan Press Second Edition; (4) Goldsby, R. A.,Kindt T. J., Osborne B. A., Kuby J., IMMUNOLOGY, W. H. Freeman & Company, New York; (5) Travers, J., Shlomchik, W., IMMUNOBIOLOGY, Garland Science publishing, New York.

MC 205 (AUG) 2:0

Pathogen - Host interactions and immune evasion mechanisms

Pathogen - Host interactions and immune evasion mechanisms 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.

Shashank Tripathi, Balaji Kithiganahalli, DipshikhaChakravortty

References :

• (1) David G. Russell and SiamonGordon,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, PurusharthRajyaguru

References :

• (1) Flint SJ, Enquist L, Racaniello V, Rall GF, Skalka AM. Principles of Virology. 4th ed. ASM Press; 2015. ISBN-10: 1555819338; (2) Knipe DM, Howley PM . Fields Virology. 6th ed. Lippincott: Williams and Wilkins; 2013. ISBN-10: 1451105630; (3) For general RNA Biology: Any standard text book and The RNA World by Gesteland, Cech, and Atkins

MC 207 (AUG) 3:0

Molecular Biology

Genome organisation, structure and complexity. Chromatin structure and remodelling. Protein nucleic acids interactions. DNA replication in prokaryotes and eukaryotes:general rules, mechanisms, and regulation. DNA modifications in epigenetic control of biological processes. DNA repair and recombination. Mechanisms and machinery of transcription in prokaryotes and eukaryotes. RNA splicing and editing. Catalytic RNAs. Transcriptional and translational regulation of gene expression. Protein splicing and repair. Small RNAs: biogenesis and their modes of action in regulation of gene expression and chromatin architecture. Group discussions and seminars on current topics in Molecular Biology.

Nagaraja V, Umesh Varshney

References :

• (1) Lewin’s Genes X, Lewin,B.,Krebs,J.E.

MC 208 (AUG) 2:0

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.

Subba Rao GangiSetty, Shashank Tripathi

References :

- (1) J. Sambrook and D. W. Russell, Molecular Cloning: A Laboratory Manual, 3rd Edn: Vol. I, II, & III, Cold Spring Harbor Laboratory Press; (2) J. J. Greene and V. B. Rao. Recombinant DNA Principles and Methodologies. CRC Press; (3) S. B. Primrose and R. M. Twyman. Principles of Gene Manipulation and Genomics, 7th Ed., Blackwell Publishing; (4) Fred Ausubel and Others. Current Protocols in Molecular Biology. Wiley; (5) 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

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, endoplasmic reticulum, 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 and Cellular diseases. Methods: Introduction and evolution of light microscopy; Electron microscopy; Cytohistochemistry; Flowcytometry; Pulse-chase and subcellular fractionation; Proteomics and Protein-protein interaction approaches and genome-wide RNAi or small molecular screens to study the various cellular pathways.

Subba Rao GangiSetty, Sachin Kotak

References :

- (1) Molecular Biology of The Cell, Fifth edition, Alberts et al.

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.

Samay Ravindra Pande, Utpal Nath, Upendra Nongthomba

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

Introduction to Cancer Biology: Immortalization, transformation, metastasis; Causes of Cancer: initiators and promoters, carcinogens, tumor viruses, sporadic and familial cancer; Genetic alterations: mutation, deletion, insertion, aneuploidy, chromosome translocation and Gene amplification; multistep carcinogenesis model; Cancer diagnosis and treatment; Cell cycle and cancer: cell cycle checkpoints, G1/S checkpoint, G2/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; Transformation by RNA and DNA tumor viruses: Adenovirus, Simian Virus 40 and Human papilloma virus, Oncogene-tumor suppressor interactions; Apoptosis and cancer, Cancer as a tissue: stroma, angiogenesis; Cancer stem cells; Cancer gene therapy.

Kumaravel Somasundaram, Annapoorni Rangarajan

References :

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

MC 211 (JAN) 3:0

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, PurusharthRajyaguru, 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,SeventhEdition,by Edward J. Masoro,Steven N. Austad,2010
- Molecular Biology of Aging (Cold Spring Harbor Monograph Series)

MC 214 (JAN) 2:0

Basic and Applied Virology

Viruses are omnipresent, in and outside of us in the environment, however in recent past they have assumed great public health significance. In last few decades viral pathogens like human immunodeficiency virus (HIV) and hepatitis viruses have caused substantial mortality, morbidity and economic loss all over the world. Moreover, in last one decade we have seen frequent emergence of viral pandemics and outbreaks potential e.g. SARS CoV2, H1N1 Swine Flu, Zika and Ebola. This course is designed to give an overview of fundamental concepts in virology, explain biology and pathogenesis of major viral pathogens and give introduction to applied aspects of virology.

Shashank Tripathi

References :

- (1) Fields Virology, 6th Edition, Edited by David M. Knipe and Peter M. Howley. Philadelphia, PA, USA. Lippincott Williams & Wilkins.
- (2) Principles of Virology, 2 Volume Set, 4th Edition, S. Jane Flint, Vincent R. Racaniello, Glenn F. Rall, Anna Marie Skalka, Lynn W. Enquist; ISBN: 978-1-683-67335-4.

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.

SrimontaGayen

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

References :
- Cell Signaling - Principles and Mechanisms; Lim, Mayer and Pawson (2015) Garland Science

RD 205 (JAN) 2:0

Genetics and Genomic Medicine

History of concepts in genetics; Genes and Genomes; Mutations; Genetic recombination and repair; 3-point cross; Tetrad analysis; GAL4-UAS system for genetic analysis; CRISPR-CAS9 system for genetic analysis; Population genetics; Types of human genetic disorders; Chromosomal aberrations in humans; Trinucleotide repeats and genetic disorders; Linkage analysis and gene discovery; Neuromuscular disorders; Genomic imprinting; Multifactorial inheritance; Genetic risk; Cancer genetics; mtDNA disorders.

Arun Kumar, Upendra Nongthomba

References :
- Essential Genetics: A Genomics Perspective, 3rd edition, Daniel L. Hartl& Elizabeth W. Jones
- Genetics, 3rd edition, Monroe W. Strickberger
- Lewin’s Genes XI by Jocelyn E. Krebbs, Elliott S. Goldstein & Stephen T. Kilpatrick
- Thompson & Thompson Genetics in Medicine, 8th edition, Robert L. Nussbaum, Roderick R. McInnes &Huntington F. Willard
- Human Molecular Genetics, Tom Strachan & Andrew P Read

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, PurusharthRajyaguru, 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

References :

- Tue, Fri 9:00

NS 203 (AUG) 2:0

Cognitive Neuroscience

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

Sridharan Devarajan, srikantPadmala

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 and cognitive neuroscience.

Aditya Murthy, Sridharan Devarajan, srikantPadmala

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 9s comprises of the Department of Inorganic and Physical Chemistry (IPC), Materials Research Centre (MRC), NMR Research Centre (NRC), Department of Organic Chemistry (OC) and Solid State and Structural Chemistry Unit (SSCU).Students with a basic/advanced degree in Chemistry, Physics, Biologyormany branches of engineering are eligible for admission to the doctoral program. 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 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 various streams at the Institute. For details concerning these requirements, students are advised to approach the Chair of the Department/Centre/Unit.

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

The Materials Research Centre provides students opportunity to learn and train on several modern sophisticated instrumental facilitiesfor 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. G. Mugesh
Dean,
Division of Chemical Sciences

Chemical Science

Integrated Phd in Chemical Science

CourseCode	CourseName	Credits
CD 204	Chemistry of Materials	3:0
CD 211	Physical Chemistry I Quantum Chemistry and Group Theory	3:0
CD 212	Inorganic Chemistry Main group and coordination chemistry	3:0
CD 213	Organic Chemistry Structure and Reactivity	3:0
CD 214	Basic Mathematics	3:0
CD 215	Organic & Inorganic Chemistry Laboratory	0:4
CD 402	Molecular Spectroscopy, Dynamics and Photochemistry	3:0
CD 221	Physical Chemistry II: Statistical Mechanics	3:0
CD 222	Material Chemistry	3:0
CD 223	Organic synthesis	3:0
CD 224	Computers in Chemistry	2:0
CD 225	Physical and Analytical Chemistry Laboratory	0:4
CD 241	Research Project	0:14
CD 301	Advanced NMR Spectroscopy	3:0

CD 204 (AUG) 3:0

Chemistry of Materials

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

Natarajan S

Pre-requisites :

- 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

Upendra Harbola

References :

- I. Levine,QuantumChemistry,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

Abhishake Mondal, Jemmis E. D

References :

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

CD 213 (AUG) 3:0

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, University Science Books, 2006.
- Carey F.A., and Sundberg R.J., Advanced Organic Chemistry, Part A. 5th ed. Plenum, 2007.
- Smith, M. B., March J., March's Advanced Organic Chemistry: Reactions, Mechanisms and Structure, 6th ed. Wiley, 2007.
- Lowry T.M. and Richardson K.S. Mechanism and Theory in Organic Chemistry, 3rd ed, Addison-Wesley-Longman, 1998.
- Current Literature.

Pre-requisites :

- Successful completion of UC201 and 205 for UG

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.

Balaram Sahoo

References :

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

CD 241 (AUG) 0:14

Research Project

Ravishankar Narayanan

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.

Sai G Ramesh

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.

PrabeerBarpanda, Karuna Kar Nanda

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, VerlogChemie 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, Subinoy Rana

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

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

Arunan E

References :

- I. N. Levine, Molecular Spectroscopy
- J. L. McHale, 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)

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 :

- P. J. Flory, Principles of Polymer Chemistry
- G. Odian, Principles of Polymerization
- P. C. Hiemenz and T. 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)

IP 326 (JAN) 3:0

Time-dependent statistical Mechanics

Brief survey of equations of motion in classical mechanics; phase space and the Liouville equation; equillibrium time correlation functions (TCF's) and their properties; simple, solvable models of TCFs; linear response theory and transport coefficients; projection operators and generalized equations of motion; functional calculus and diffusion equations, including Fokker-Planck ad Smoluchowski equations; chemical reaction dynamics and the Kramers equation; stochastic processes in biology; fluctuation theorems in far from equillibrium systems

Binny J Cherayil

References :

- D. A. McQuarrie, Statistical Mechanics
- R. Zwanzig, Nonequillibrium Statistical Mechanics
- V. Balakrishnan, Elements of Nonequilibrium Statistical Mechanics

Pre-requisites :

- A course in equillibrium statistical mechanics

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.

Balaram Sahoo, Karuna Kar Nanda

References :

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

MR 309 (AUG) 3:0

Introduction to Supramolecular Chemistry

Course description: Supramolecular chemistry is “chemistry beyond the molecule”. It is an interdisciplinary field that covers the physical, chemical and biological properties of complex chemical species held together mainly by non-covalent interactions. This course provides an introduction to the field, and discusses the intermolecular forces that dictate the formation of supermolecules and supramolecular assemblies and their properties. In addition, current trends are discussed using recent publications in this area. Course outline: This course is designed to be modular and includes the following topics: Molecular recognition, Host-Guest Chemistry; Receptors, Coordination and the “Lock and Key” Analogy; Chelate, Conformational and Macrocyclic Effects; Pre-organisation and Complementarity; Thermodynamic and Kinetic Selectivity; Selectivity and Solution Behaviour of Crown Ethers, Cryptands, Spherands; Complexation of Organic Cations; Biological anion receptors; Anti-crowns and Coordination Interactions; Inorganic Solid-State Clathrate compounds; clathrates of organic hosts, intracavity complexes of neutral molecules (Fullerenes, Cucurbiturils, and Cyclodextrins): Solution and Solid State Binding; Metal organic frameworks (MOF); Catenanes, Rotaxanes and Helicates; Role of Positive Cooperativity; Structure and function of DNA; Supramolecular Reactivity, Liquid Crystals, Dendrimers, MOF’s, Electronic devices (switches, wires and rectifiers) and non-linear optical materials.

Subinoy Rana

References :

- • Supramolecular Chemistry. J. W. Steed, J. L. Atwood, John Wiley and Sons, 2000. • Supramolecular Chemistry. Concepts and Perspectives. J. -M. Lehn. VCH, 1995. • Principles and Methods in Supramolecular Chemistry. H.-J. Schneider, A.Yatsimirsky, John Wiley and Sons.

Pre-requisites :

- The course is open to all PhD, Master and Undergraduate (3rd year or higher) students having done basic organic chemistry

Organic Chemistry

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.

Mrinmoy De, Uday Maitra

Pre-requisites :
- Anslyn,E.V.,andDougherty,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.

Pre-requisites :
- Basic principles of Organic Chemistry, Basic Structural knowledge of molecules.

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,OrganicSynthesis,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

Jayaraman N

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 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

SS 201 (AUG) 3:0

Thermodynamics and Statistical Mechanics

Review of thermodynamics, postulates, ensembles, classical and quantum statistics. Application to blackbody radiation, Bose-Einstein Condensation, electron conduction in metals, specific heats of solids, classical fluids and phase transitions.

Govardhan P Reddy

References :

- H.B. Callen, Thermodynamics and an Introduction to Thermo Statistics
- E. Fermi, Thermodynamics
- D. A. McQuarrie, Statistical Mechanics
- D. Chandler, Introduction to Modern Statistical Mechanics.

Pre-requisites :

- Basic Thermodynamics

SS 202 (AUG) 3:0

Introductory Quantum Chemistry

Basic Postulates of Quantum Mechanics, Commutation Relations, Ladder Operators. Exact Solutions Using Ladder Operator Approach - Harmonic Oscillator, Hydrogen atom. Approximate Methods - Time-independent and Time-dependent Perturbation Theory. Variation Methods - Raleigh-Ritz Variation, Huckle Theory, Hartree-Fock Theory, Variational Configuration Interaction, Moller-Plesset Perturbation Theory. Note - the above list of topics is not an exhaustive list of topics which will be covered in the class.

Vivek Tiwari

References :

- 1. Cohen-Tannoudji, Diu and Laloe, Quantum Mechanics. 2. J.J. Sakurai, Modern Quantum Mechanics, 3. A. Szabo and N. Ostlund, Modern Quantum Chemistry

Pre-requisites :

- Ira Levine, Quantum Chemistry and P.W. Atkins, Molecular Quantum Mechanics

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 elementary electrolyte theory and its applications to electrochemical systems such as batteries, fuel cells, electrochemical transistors. Introduction to heterogeneous catalysis and mass transport in electrochemical systems will also be covered.

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.

Anshu Pandey, Satish Amrutrao Patil

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. Kaushal Verma
Dean
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 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.,andHill,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 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.

ParthaPratim Mondal

References :
- Book

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

IN 270 (AUG) 3:0

Digital Signal Processing

Review of Signals and Systems, Need for DSP, LTI systems, Fourier analysis, Fourier Integral, Sampling and Quantization, Requirements for Perfect Reconstruction, Discrete Fourier transform and its properties, Z-transform and its properties, linear and circular convolution, Impulse Invariance Method and Bilinear Transformation, Filter Design, IIR Filter - Butterwort and Chebyshev Filter Design, FIR Filter - Windowing Methods and Parks-McClellan Algorithm, Gibbs Phenomenon, DFT Computation - Decimation in Time and Decimation in Frequency, Short-time Fourier Transform and Wavelet Transform, Hilbert Transform, Introduction to sparse signal processing, compressive sensing algorithms, Applications of transforms.

Jaya Prakash

References :
- John G. Proakis and Dimitris G. Manolakis, "Digital Signal Processing: Principles, Algorithms and Applications," 4th Edition, Pearson Education (2006).
- Alan V. Oppenheim and Roland W, Schafer, "Discrete-time Signal Processing," 3rd Edition, Pearson Education (2013).
- Sanjit K. Mitra, "Digital Signal Processing: A Computer - Based Approach," 4th Edition, McGraw Hill Education (2013).
- Current Literature

Pre-requisites :
- Signals and Systems

IN 201 (JAN) 3:0

Fundamentals of Metamaterials

Fundamental physics, the designs and the engineering aspects of metamaterials, phononic and photonic metamaterials, bandgap materials, three-dimensional and two-dimensional metasurfaces, nanostructured plasmonic surfaces, MEMS fabrication, effective media with single and double negative properties, state-of-the-art applications for antennas, waveguides, cloaking metamaterial, devices and components, Sensing applications.

AbhaMisra

References :
- -Metamaterials: Physics and Engineering Explorations, Publisher: Wiley-Blackwell, Edited by Nader Engheta and Richard W. Ziolkowski

Pre-requisites :
- None

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) 2:1

Sensors and Transducers Laboratory

Sensor development and signal processing, temperature sensor, hall sensor, noise analysis, Dynamic modeling and system identification, DC motor, Induction motor, water bath, Actuation, piezo-actuation, bimetallic strip, magnetic actuation, Control systems, One degree of freedom control, two degree of freedom control, PID control, Lead-lag compensation

Atanu Kumar Mohanty, Jayanth G R, Sanjiv Sambandan, Sai Siva Gorthi, Chandni U, Asha Bhardwaj, Dr. Baladitya Suri

References :

- 1. W. Bolton, Mechatronics, Longman, 2015

Pre-requisites :

- IN 221

IN 223 (JAN) 3:0

Advanced Signal Processing

Signals and Systems Review, LTI Systems, Signal Processing Review: DFT and its properties, Nyquist Sampling Theorem, Low-Pass Filtering, Filters - Chebyschev Filter and Butterworth Filter, Multi-resolution analysis, Filter Banks, Wavelets, Reconstruction of Bandlimited Signals. 1D & 2D signals and its property, Sub-Nyquist Sampling, Reconstruction with uniform and non-uniform sampling (prior constraints): Pseudo-inverse, Truncated SVD, Minimum Norm Solution, Tikhonov Regularization, Iterative Methods, Half-Quadratic Regularization, Interpolation & Splines, Majorization-Minimization, and Compressive Sampling. Algorithms based on compressive sensing. Noise Distribution & Error Analysis, Application of signal processing (non-uniform sampling) - MRI, CT - Fourier Slice Theorem.

Jaya Prakash

References :

- John G. Proakis and Dimitris G. Manolakis, Digital Signal Processing: Principles, Algorithms and Applications, Pearson Publication, 4th Edition (2007).

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 assembledInAs 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, SumitaPennathur
- 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 244 (JAN) 2:1

Optical Metrology

Sai Siva Gorthi

IN 252 (JAN) 3:0

Optical materials and devices

Introduction, Fundamentals of semiconductors and optoelectronic devices, photodetector, LED, LASER, optical properties of thin films and noble metals, Fabrication methods- chemical and physical techniques, Surface Plasmon Polariton, Metasurface, Metasurface applications in sensing and non-linear light generation, Optical fibers and Waveguides, Fiber drawing process, Fiber materials, multi-material micro-structured fibers, multi-material fibers for electronic and photonic applications, Integrated photonics-material choice and applications

Tapajyoti Das Gupta

References :

- 1- Solid State Physics; Ashcroft, Neil W., and N. David Mermin; Belmont, CA 2- Introduction to Solid State Physics; Kittel, Charles; Hoboken, NJ: Wiley 3- Elements of Photonics; For Fiber and Integrated Optics, Vol. 2; Keigo Iizuka; Wiley-Interscience 4- Flat optics with designer metasurfaces, Nature Materials volume 13, pages139–150(2014)

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,“QuantumMeasurement”,Cambridge University Press,1995,Howard M. Wiseman

IN 299 (JAN) 0:19

Dissertation Project

Dept of Mathematics

The department is active in research in most areas of pure and applied mathematics, including algebra and number theory, analysis, discrete mathematics, geometry/topology, mathematical finance, numerical analysis, partial differential equations, probability, representation theory, and time-series analysis.

The department has a Ph.D. programme as well as an integrated Ph.D. programme. The department participates in the undergraduate programme of IISc: undergraduate students can opt for mathematics as a major or a minor.

Courses Offered in AUG 2020 Semester:

Course Number	Credits	Course Name	Nature
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 226	3:0	Complex Analysis II	Elective
MA 302	3:0	Mechanics	Elective
MA 307	3:0	Riemann Surfaces	Elective
MA 308	3:0	Basic Algebraic Geometry	Elective
MA 326	3:0	Fourier Analysis	Elective
MA 336	3:0	Topics in Riemannian Geometry	Elective
MA 354	3:0	Topics in Number Theory	Elective
MA 361	3:0	Probability Theory	Elective
MA 365	3:0	Topics in Gaussian Processes	Elective
MA 381	3:0	Topics in Several Complex Variables	Elective

Courses Offered in JAN 2021 semester:

Course Number	Credits	Course Name	Nature
MA 213	3:1	Algebra II	Core
MA 222	3:1	Measure & Integration	Core
MA 224	3:1	Complex Analysis	Core

MA 229	3:0	Calculus on Manifolds	Core
MA 241	3:1	Ordinary Differential Equations	Core
MA 215	3:0	Introduction to Modular Forms	Elective
MA 278	3:0	Introduction to Dynamical Systems Theory	Elective
MA 304	3:0	Topics in Harmonic Anaysis	Elective
MA 312	3:0	Commutative Algebra	Elective
MA 319	3:0	Algebraic Combinatorics	Elective
MA 321	3:0	Analysis III	Elective
MA 338	3:0	Differentiable Manifolds & Lie Groups	Elective
MA 363	3:0	Probability in higher dimensions	Elective
MA 380	3:0	Introduction to Complex Dynamics	Elective

MA 200 (AUG) 3:1

Multivariable Calculus

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

Harish Seshadri

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.

Mahesh Ramesh Kakde, Soumya Das

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 219 (AUG) 3:1

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.

Apoorva Khare

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 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.

ThirupathiGudi

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.

GadadharMisra

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 226 (AUG) 3:0

Complex Analysis II

Harmonic and subharmonic functions, Green's function, and the Dirichlet problem for the Laplacian; the Riemann mapping theorem (revisited) and characterizing simple connectedness in the plane; Picard's theorem; the inhomogeneous Cauchy–Riemann equations and applications; covering spaces and the monodromy theorem.

Kaushal Verma

References :
- Narasimhan, R., Complex Analysis in One Variable, 1st ed. or 2nd ed. (with Y. Nievergelt), Birkhauser (2nd ed. is available in Indian reprint, 2004).
- Greene, R.E. and Krantz, S.G., Functions Theory of One Complex Variable, 2nd ed., AMS 2002 (available in Indian reprint, 2009, 2011).

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.

Basudeb Datta

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.

Mrinal Kanti Ghosh

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 302 (AUG) 3:0

Mechanics

This is an introductory course on the foundations of mechanics, focusing mainly on classical mechanics. The laws of classical mechanics are most simply expressed and studied in the language of symplectic geometry. This course can also be viewed as an introduction to symplectic geometry. The role of symmetry in studying mechanical systems will be emphasized. The core syllabus will consist of Lagrangian mechanics, Hamiltonian mechanics, Hamilton-Jacobi theory, moment maps and symplectic reduction. Additional topics will be drawn from integrable systems, quantum mechanics, hydrodynamics and classical field theory.

Kaushal Verma

References :

- Ralph Abraham and Jerrold E. Marsden, Foundations of mechanics, Benjamin/Cummings Publishing Co., Inc., Advanced Book Program, Reading, Mass., 1978.
- Vladimir I. Arnol'd, Mathematical methods of classical mechanics, Graduate Texts in Mathematics, vol. 60, Springer-Verlag, New York, 1989.
- Ana Cannas da Silva, Lectures on symplectic geometry, Lecture Notes in Mathematics, vol. 1764, Springer-Verlag, Berlin, 2001.
- Jerrold E. Marsden and Tudor S. Ratiu, Introduction to mechanics and symmetry, second ed., Texts in Applied Mathematics, vol. 17, Springer-Verlag, New York, 1999.

Pre-requisites :

- Calculus on manifolds; rudiments of Lie theory (the equivalent of Chapter 1, Chapter 2, and Section 4.1 of "Foundations of mechanics" by Abraham and Marsden).

MA 307 (AUG) 3:0

Riemann surfaces

Riemann surfaces are one-dimensional complex manifolds, obtained by gluing together pieces of the complex plane by holomorphic maps. This course will be an introduction to the the theory of Riemann surfaces, with an emphasis on analytical and topological aspects. After describing examples and constructions of Riemann surfaces, the topics covered would include branched coverings and the Riemann-Hurwitz formula, holomorphic 1-forms and periods, the Weyl's Lemma and existence theorems, the Hodge decomposition theorem, Riemann's bilinear relations, Divisors, the Riemann-Roch theorem, theorems of Abel and Jacobi, the Uniformization theorem, Fuchsian groups and hyperbolic surfaces.

Subhojoy Gupta

References :
- H.M. Farkas and I. Kra, Riemann surfaces, Springer GTM 1992.
- R. Miranda, Algebraic Curves and Riemann Surfaces, AMS Graduate Studies in Mathematics, 1995
- W. Schlag, A Course in Complex Analysis and Riemann surfaces, AMS Graduate Studies in Mathematics, 2014.

Pre-requisites :
- Topology (MA 231) or equivalent
- Complex Analysis (MA 224) or equivalent
- Introduction to Algebraic Topology (MA 232) or equivalent.

MA 308 (AUG) 3:0

Basic Algebraic Geometry

The material to be covered will include: Affine algebraic sets: Zariski topology, irreducible components, Hilbert Nullstellensatz theorem, maps of algebraic sets Algebraic varieties: Definitions, affine algebraic varieties, projective varieties, morphisms Rational functions and rational maps Algebraic curves, B´ezout's theorem * Reimann-Roch theorem

Radhika Ganapathy

References :
- William D. Fulton, Algebraic curves, available free (and legally) at http://www.math.lsa.umich.edu/ wfulton/CurveBook.pdf.

Pre-requisites :
- Algebra II (MA 213)
- The course will assume that that the student is comfortable with Abstract Algebra at the level of Galois theory.

MA 326 (AUG) 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.

Thangavelu S

References :
- 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.

Pre-requisites :
- MA 223

MA 336 (AUG) 3:0

Topics in Riemannian Geometry

Bochner formula, Laplace comparison, Volume comparison, Heat kernel estimates, Cheng-Yau gradient estimates, Cheeger-Gromoll splitting theorem, Gromov-Haudorff convergence, epsilon regularity, almost rigidity, quantitative structure theory of Riemannian manifolds with Ricci curvature bounds. If time permits, we will discuss the proof of the co-dimension four conjecture due to Cheeger and Naber.

Ved V Datar

References :
- Peter Petersen, Riemannian geometry, Graduate Texts in Mathematics, 171. Springer-Verlag, New York, 1998.
- Richard Schoen and ST Yau, Lectures of Differential Geometry, International Press, 1997.
- Jeff Cheeger, Degenerations of Riemannian metrics under Ricci curvature bounds, Publications of the ScuolaNormaleSuperiore, Birkhauser, 2001.

Pre-requisites :
- MA 333 - Riemannian Geometry

MA 354 (AUG) 3:0

Topics in Number Theory

The goal is to give an introduction to adeles and some of their uses in modern number theory, discussing also some topics which are not too common in textbooks. Topics to be covered: absolute values and Ostrowski's Theorem; classification of locally compact fields; definition of adeles and some applications (finiteness of class number and of the generators of the group of S-units; structure of modules over Dedekind domains; applications to the geometry of curves); an introduction to the Strong Approximation Theorem; adelic points of varieties and schemes; possibly other topics (depending on time left and interests of the audience; for example Tate's thesis, quasi-characters of the idele class group and p-adic L-functions).

Mahesh Ramesh Kakde

References :

- J. W. S. Cassels and A. Fröhlich (editors), Algebraic Number Theory, Papers from the conference held at the University of Sussex, Brighton, September 1–17, 1965.
- A. Weil, Basic Number Theory, Classics in Mathematics, Springer 1974.
- B. Conrad, Weil and Grothendieck approaches to adelic points, Enseign. Math. (2) 58 (2012), no. 1-2, 61–97.

Pre-requisites :

- a good background in commutative algebra (inverse limits, I -adic completion, Galois theory, possibly some familiarity with Dedekind domains)
- some previous knowledge of algebraic number theory should be useful.

MA 361 (AUG) 3:0

Probability theory

Review of Measure Theory, various modes of convergence of random variables, convergence of random series, laws of large numbers, weak convergence of probability measures, central limit theorems, infinitely divisible and stable laws, conditional expectation with respect to sigma algebra, discrete parameter martingales.

Srikanth Krishnan Iyer

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 365 (AUG) 3:0

Topics in Gaussian Processes

A course in Gaussian processes. At first we shall study basic facts about Gaussian processes - isoperimetric inequality and concentration, comparison inequalities, boundedness and continuity of Gaussian processes, Gaussian series of functions, etc. Later we specialize to smooth Gaussian processes and their nodal sets , in particular expected length and number of nodal sets, persistence probability and other such results from recent papers of many authors.

Manjunath Krishnapur

References :

- Robert Adler and Jonathan Taylor, Gaussian Random Fields, Springer, New York, 2007.
- A. I. Bogachev, Gaussian Measures, American Mathematical Society, Providence, RI, 1998
- Svante Janson, Gaussian Hilbert Spaces, Cambridge University Press, Cambridge, 1997.

Pre-requisites :

- MA 361

MA 381 (AUG) 3:0

Topics in Several Complex Variables II

The aim of this course is to provide an introduction to CR (Cauchy Riemann/Complex Real) geometry, which is broadly the study of the structure(s) inherited by real submanifolds in complex spaces. We will first give a parallel introduction to the fundamental objects of SCV and CR geometry. These include holomorphic functions in several variables, CR manifolds (embedded and abstract) and CR functions. Next, we will cover some examples, results, and techniques from the following range of topics: a) embeddability of abstract CR structures; b) holomorphic extendability of CR functions; c) CR singularities. Wherever possible (and time permitting), we will highlight the connections of this field to other areas of analysis and geometry. For instance, abstract CR structures will be discussed in the broader context of involutive structures on smooth manifolds.

Purvi Gupta

References :

- A. Boggess, CR Manifolds and the tangential Cauchy-Riemann complex, CRC Press, Boca Raton, FL (1991).
- M. S. Baouendi, P. Ebenfelt, and L. P. Rothschild, Real Submanifolds in Complex Space and their Mappings, Princeton Math. Series., Princeton Univ. Press (1999).

Pre-requisites :

- MA 224 (Complex Analysis)
- Basic familiarity with: differentiable manifolds, tangent and cotangent bundles, and systems of (first order) PDEs.

MA 399 (AUG) 2:0

Seminar on topics in Mathematics

MA 201 (JAN) 7:0

Project

Integrated PhD project

ThirupathiGudi

MA 213 (JAN) 3:1

Algebra II

Part A: Field theory (1) Theory of symmetric polynomials – Newton's theorem (2) Basic theory of field extensions (3) Algebraic and transcendental extensions (and transcendence degree) (4) Construction with straight edge and compass; Gauss-Wantzel theorem (5) Algebraic closure – Steinitz's theorem (6) Splitting fields, normal extensions (7) Separable extensions (8) Finite fields: construction, subfields, Frobenius (9) Primitive element theorem (10) Dedekind-Artin linear independence of (semi)group characters Part B: Galois theory (1) Fundamental theorem of Galois theory (including Normal Basis Theorem) (2) Composite extensions and Galois group (3) Galois group of cyclotomic extensions, finite fields (4) Galois groups of polynomials, Fundamental theorem of Algebra (5) Solvable and radical extensions, insolvability of a quintic

Radhika Ganapathy

References :

- 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
- Jonathan Alperin and Rowen Bell, Groups and Representations, Graduate Texts in Mathematics 162, Springer Verlag, 1995.
- Hungerford, Algebra, Graduate Texts in Mathematics 73, Springer Verlag, 1974.
- Galois Theory, Artin, E., University of Notre Dame Press, 1944.
- Nathan Jacobson, Basic Algebra I & II, Dover, 2009.
- Nathan Jacobson, Lectures in Abstract Algebra I, II & III, Graduate Text in Mathematics, Springer Verlag, 1951.

Pre-requisites :

- MA 212

MA 215 (JAN) 3:0

Introduction to Modular Forms

The modular group and its subgroups, the fundamental domain. Modular forms, examples, Eisenstein series, cusp forms. Valence (dimension) formula, Petersson inner product. Hecke operators. L-functios: definition, analytic continution and functional equation.

Soumya Das

References :
- Serre, J.P., A Course in Arithmetic, Graduate Texts in Mathematics no. 7, Springer-Verlag, 1996.
- Koblitz, N., Introdution to Modular Forms, Graduate Texts in Mathematics no. 97, Springer-Verlag, 1984.
- Iwaniec, H., Topics in Classical Automorphic Forms, Graduate Texts in Mathematics 17, AMS, 1997.
- Diamond, F. and Schurman, J., A First Course in Modular Forms, Graduate Texts in Mathematics no. 228, Springer-Verlag, 2005.

Pre-requisites :
- MA 224

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.

Manjunath Krishnapur

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).

Purvi Gupta

References :
- 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.

Pre-requisites :
- MA 221

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.

Ved V Datar

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

Pre-requisites :
- MA 221

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

Nandakumaran A K

References :
- 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.

Pre-requisites :
- MA 221

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.

Thangavelu S

MA 304 (JAN) 3:0

Topics in Harmonic Analysis

Syllabus: Fractional powers of Laplacian $ \Delta $ on $ \R^n $ and sublaplacian $ \mathcal{L} $ on Heisenberg groups. Complementary series representations. Branching problem. Poisson transforms. Extension problem for $ \Delta $ and $ \mathcal{L}.$ Trace Hardy inequality. Hardy's inequality for conformally invariant fractional powers of $ \Delta $ and $ \mathcal{L}.$ Some applications to PDE and spectral theory of Schrodinger operators.

Thangavelu S

References :
- L. A. Caffarelli and L. Silvestre, {An extension problem related to the fractional Laplacian}, \textit{Comm. Partial Differential

Equations} \textbf{32} (2007), 1245--1260. S-Y. A. Chang and M.d.M.Gonz\'alez, {Fractional Laplacian in conformal geometry}, \textit{Adv. Math.} \textbf{226} (2011), no. 2, 1410--1432. R. L. Frank, M.d.M.Gonz\'alez, D. D. Monticelli and J. Tan, An extension problem for the CR fractional Laplacian, \emph{Adv. Math.} \textbf{ 270} (2015), 97--137. R. L. Frank and E. H. Lieb, {Sharp constants in several inequalities on the Heisenberg group}, \emph{Ann. Math. (2)} \textbf{176} (2012), 349--381. J. M\"ollers, B. \O rsted and G. Zhang, {On boundary value problems for some conformally invariant differential operators}, \textit{Comm. Partial Differential Equations} \textbf{41} (2016), no. 4, 609--643. L. Roncal and S. Thangavelu, {Hardy's inequality for fractional powers of the sublaplacian on the Heisenberg group}, \emph{Adv. Math.} {\bf 302} (2016), 106--158. L. Roncal and S. Thangavelu, {An extension problem and trace Hardy inequality for the sublaplacian on H-type groups}, \emph{IMRN}, (to appear)

Pre-requisites :
- Basic Fourier Analysis and Partial Differential Equations.

MA 312 (JAN) 3:0

Commutative Algebra

Noetherian rings and Modules, Localisations, Exact Sequences, Hom, Tensor Products, Hilbert's Null-stellensatz, Integral dependence, Going-up and Going down theorems, Noether's normalization lemma , Discrete valuation rings and Dedekind domains.

Abhishek Banerjee

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 groubs 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 321 (JAN) 3:0

Analysis III

Theory of Distributions: Introduction, Topology of test functions, Convolutions, Schwartz Space, Tempered distributions. Fourier transform and Sobolev-spaces:Definitions, Extension operators, Continuum and Compact imbeddings, Trace results. Elliptic boundary value problems: Variational formulation, Weak solutions, Maximum Principle, Regularity results.

Narayanan E K

References :
- Barros-Nato, An Introduction to the Theory of Distributions, Marcel Dekker Inc., New York, 1873.
- Kesavan, S., Topics in Functional Analysis and Applications, Wiley Eastern Ltd., 1989.
- Evans, L. C., Partial Differential Equations, Univ. of California, Berkeley, 1998.
- Schwartz, L. Hermann, Theorie des Distributions, 1966.

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.

Subhojoy Gupta

References :

- 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.

Pre-requisites :

- MA 219, MA 231

MA 363 (JAN) 3:0

Probability in higher dimensions

This course will be aimed at understanding the behavior of random geometric objects in high dimensional spaces such as random vectors, random graphs, random matrices, and random subspaces, as well. Topics will include the concentration of measure phenomenon, non-asymptotic random matrix theory, chaining and Gaussian processes, empirical processes, and some related topics from geometric functional analysis and convex geometry. Towards the latter half of the course, a few applications of the topics covered in the first half will be considered such as community detection, covariance estimation, randomized dimension reduction, and sparse recovery problems.

Thangavelu S

References :

- Roman Vershynin, High-dimensional probability: An introduction with Applications in Data Science, Cambridge Series in Statistical and Probabilistic Mathematics (Series Number 47), 2018.
- Roman Vershynin, Introduction to the non-asymptotic analysis of random matrices, Compressed sensing, 210-268, Cambridge University Press, 2012.
- Stéphane Boucheron, Gábor Lugosi, and Pascal Massart, Concentration Inequalities: A nonasymptotic theory of independence, Oxford University Press, 2013.
- Michel Ledoux and Michel Talagrand, Probability in Banach spaces, Springer Science & Business Media, 2013.
- Avrim Blum, John Hopcroft, and Ravindran Kannan, Foundations of Data Science, Cambridge University Press, 2020.
- Joel Tropp, An Introduction to Matrix Concentration Inequalities, Foundations and Trends in Machine Learning, Vol. 8, No. 1-2, pp 1-230, 2015..

Pre-requisites :

- Graduate level measure theoretic probability will be useful, but not a requirement.
- Students are expected to be familiar with basic probability theory and linear algebra.

MA 380 (JAN) 3:0

Introduction to Complex Dynamics

The dynamics alluded to by the title of the course refers to dynamical systems that arise from iterating a holomorphic self-map of a complex manifold. In this course, the manifolds underlying these dynamical systems will be of complex dimension 1. The foundations of complex dynamics are best introduced in the setting of compact spaces. Iterative dynamical systems on compact Riemann surfaces other than the Riemann sphere – viewed here as the one-point compactification of the complex plane – are relatively simple. We shall study what this means. Thereafter, the focus will shift to rational functions: these are the holomorphic self-maps of the Riemann sphere. Along the way, some of the local theory of fixed points will be presented. In the case of rational maps, some ergodic-theoretic properties of the orbits under iteration will be studied. The development of the latter will be self-contained. The properties/ theory coverd will depend on the time available and on the audience's interest.

Gautam Bharali

References :

- J. Milnor, Dynamics in One Complex Variable, Annals of Mathematics Studies no. 160, Princeton University Press, 2006.
- A.F. Beardon, Iteration of Rational Functions: Complex Analytic Dynamical Systems, Graduate Texts in Mathematics no. 132, Springer-Verlag, 1991.

MA 399 (JAN) 2:0

Seminar in Topics in Mathematics

Kaushal Verma

Department of Physics

The department of Physics offers three post-undergraduate courses: Integrated PhD Physics (I-PhD), PhD Physics, and PhD in Joint Astronomy Programme (JAP).

The I-PhD programme in Physics requires finishing total 64 credits of core and elective courses in the first two years after joining. The elective courses can be chosen across various departments in IISc after consulting faculty mentors. The PhD Physics students can take any of the courses offered in the department after consulting with their PhD supervisor. The students must finish 12 credits.

The JAP PhD students must take a set of core courses (total 15 credits) in the first year of their programme.

Departmental I-PhD Core Courses

Sl. No	Course No.	Credits	Course title	Nature	Term
1	PH 201	3:0	Classical Mechanics	Core	August
2	PH 202	3:0	Statistical Mechanics	Core	Jan
3	PH 203	3:0	Quantum Mechanics I	Core	August
4	PH 204	3:0	Quantum Mechanics II	Core	Jan
5	PH 205	3:0	Mathematical Methods of Physics	Core	August
6	PH 206	3:0	Electromagnetic Theory	Core	Jan
7	PH 207	1:2	Analog Digital and Microprocessor Electronics	Core	Jan
8	PH 208	3:0	Condensed Matter Physics-I	Core	Jan
9	PH 211	0:3	General Physics Laboratory	Core	August
10	PH 212	0:3	Experiments in Condensed Matter Physics	Core	Jan
11	PH 213	0:4	Advanced Experiments in Condensed Matter Physics	Core	August
12	HE 215	3:0	Nuclear and Particle Physics	Core	August
13	PH 217	3:0	Fundamentals of Astrophysics	Core	August
14	PH 231	0:1	Workshop practice	Core	August
15	PH 300	1:0	Seminar Course	Core	August
16	PH 330	0:3	Advanced Independent Project	Core	August

Project:

Sl. No	Course No.	Credits	Term
01	**PH 250A**	**0:6**	**January**
02	**PH 250B**	**0:6**	**May-June**

JAP Core Courses :

Sl. No	Course No.	Credits	Course title	Nature	Term
1	PH 217	3:0	Fundamental of Astrophysics	Core	Aug
2	PH 362	2:0	Radiative Processes in Astrophysics	Core	Aug
3	PH 363	2:0	Introduction to Fluid Mechanics and Plasma Physics	Core	Aug
4	PH 365	3:0	Galaxies and the Interstellar Medium	Core	Jan
5	PH 371	3:0	General Relativity and Cosmology	Core	Jan
6	PH 377	0:2	Astronomical Techniques	Core	Jan

Elective Courses:

#	Course No.	Credits	Course title	Nature	Term
1	PH 320	3:0	Condensed Matter Physics II	Elective	August
2	PH 322	3:0	Molecular Simulation	Elective	Jan
3	PH 325	3:0	Advanced Statistical Physics	Elective	August
4	PH 333	3:0	Physics of Disordered Systems	Elective	Jan
5	PH 335	3:0	Modern topics in condensed matter	Elective	Jan
6	PH 340	4:0	Quantum Statistical Field Theory	Elective	Jan
7	PH 350	3:0	Physics of Soft Condensed Matter	Elective	Jan
8	PH 351	3:0	Crystal Growth, Thin Films and Characterization	Elective	August
9	PH 352	3:0	Semiconductor Physics and Technology	Elective	Jan
10	PH 353	3:0	Principles of Magnetism in Solids	Elective	Aug
11	PH 354	3:0	Computational Physics	Elective	Jan
12	PH 359	3:0	Physics at the Nanoscale	Elective	Jan

13	PH 360	3:0	Biological Physics	Elective	Aug
14	PH 364	3:0	Topological Phases of Matter (Theory and experiment)	Elective	Jan
16	PH 366	3:0	Physics of Advanced Optical Materials	Elective	Jan

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.

AnimeshKuley

References :
- Goldstein,H.,ClassicalMechanics,SecondEdn,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.,andLaloe

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.,andWalker,R.L.,Mathematical Methods of Physics

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

Prasad Vishnu Bhotla, Victor Suvisesha Muthu D

Pre-requisites :
- practical course,practicalcourse,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,practicalcourse,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.

Nirupam Roy, Banibrata Mukhopadhyay

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,practicalcourse,practical course

PH 300 (AUG) 1:0

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.

Akshay Singh, Anindya Das

Pre-requisites :

- Seminar course,SeminarCourse,SeminarCourse,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.,andMermin,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.

Sriram Ramaswamy, Subroto Mukerjee

Pre-requisites :

- Chaikin,P.M.,andLubensky,T.C.,Principles of Condensed Matter Physics

PH 330 (AUG) 0:3

Advanced Independent Project

Pre-requisites :
- Project Course,ProjectCourse,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 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.

Nirupam Roy

References :
- It will be taught by Prof.Arun Mangalam (IIA)

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 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.

Aninda Sinha

Pre-requisites :

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

PH 202 (JAN) 3:0

Statistical Mechanics

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

Justin Raj David

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 204 (JAN) 3:0

Quantum Mechanics II

Minimal coupling between radiation and matter, diamagnetism and paramagnetism of atoms. Addition of angular momenta, Clebsch-Gordan coefficients, Wigner-Eckart theorem, Lande's g factor. Many-particle systems: identity of particles, Pauli principle, exchange interaction, bosons and fermions. Multielectron atoms, Hund's rules. Binding of diatomic molecules. Scattering theory: partial wave analysis, low energy scattering, scattering length, Born approximation, optical theorem, resonances. Born cross section for weak potential scattering. WKB method for bound states and tunneling. Time-dependent perturbation theory. Fermi golden rule. Adiabatic and sudden approximations. Geometric phase. Second quantization of electromagnetic field. Transitions caused by a periodic external field. Dipole transitions and selection rules.

Diptiman Sen

References :

- Schwabl, F., Quantum Mechanics. Landau, L.D., and Lifshitz E.M., Quantum Mechanics. Cohen-Tannoudji, C., Diu, B., and Laloe, F., Quantum Mechanics (2 Vols.). Bethe, H. and Jackiw, R., Intermediate Quantum Mechanics.

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.

Prasad Satish Hegde

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.

Vibhor Singh

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.

Vijay B Shenoy

References :

- Ashcroft,N.W.,andMermin,N.D.,Solid State Physics

PH 212 (JAN) 0:3

Experiments in Condensed Matter

Stirling Engine, Thinfilm deposition by thermal evaporation technique, Low temperature measurement (using closed cycle helium cryostat), Scanning Tunneling Microscope, Atomic Force Microscope, Franck-Hertz experiment, Laue Pattern of single crystal, Thermogenerator (Peltier and Seeback effect), Alpha Scattering, Lock-in Amplifier.

Akshay Singh, Anindya Das

PH 250 (JAN) 0:6

Project I

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

Subroto Mukerjee

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

PH 250A (JAN) 0:6

Project I

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

Subroto Mukerjee, 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 340 (JAN) 3:0

Quantum Statistical Field Theory

Physics

Tanmoy Das

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

Prateek Sharma, Prabal Kumar Maiti

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

Aveek Bid

References :

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

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.

Ambarish Ghosh, Jaydeep Kumar Basu

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.

Rajeev Kumar Jain

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

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.

Chethan Krishnan

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/

Centre for High Energy Physics

CHEP started a Ph.D. programme from the academic year 1996-97. The minimum qualification for applying is an M.Sc. in Physics, Mathematics or Chemistry, or a B.E./B.Tech. degree. The programme is oriented towards research in theoretical and experimental high energy physics as well as mathematical physics. General research areas include: quantum field theory, the standard model of particle physics and beyond, new particle searches, collider data analysis, detector physics and fabrication, QCD and lattice gauge theories, quantum gravity, string theory and black holes, non-commutative geometry, quantum computation, condensed matter systems in low dimensions. The research interests of individual faculty members can be found in their respective home pages under Personnel. The advertisement, examination, interview procedure, etc. are part of the overall procedure followed by IISc. The interviews for the CHEP programme are conducted by a departmental committee. After admission, basic knowledge of the incoming students in the following subjects is checked: Classical mechanics, Electromagnetic theory, Mathematical physics, Quantum mechanics, Thermodynamics and statistical physics. During the first year, students are expected to fill up gaps in their knowledge, if necessary by solving a set of problems on the subjects.
Course requirements:

First semester		Second semester	
Quantum Field Theory I	3:0	The Standard Model of Particle Physics	3:0
Elective E1 (Two)	6:0	Elective E2 (None to Two)	0/3:0/6:0
	9		3/9

Third semester	
Elective E3 (None or One)	0/3:0
	0/3

The minimum course credit requirement for the IISc Ph.D. programme is 12. The total course credit requirement for CHEP students can be higher---the list above ranges from 12 to 21 credits (because of the extra electives). The DCC may advise students to take these extra electives depending on their research area.
Electives (some electives may not be offered every year):
E1: Nuclear and Particle Physics (3:0),
Quantum Mechanics III (3:0)
Experimental High Energy Physics (3:0),
Advanced Statistical Physics (3:0),
Condensed Matter Physics II (3:0).

E2: Advanced Mathematical Methods in Physics (3:0),
Quantum Field Theory II (3:0),
General Relativity (3:0),
Quantum Statistical Field Theory (3:0),
Quantum Computation (3:0),
String Theory (3:0),
QCD and Collider Physics (3:0).

E3: ADS/CFT as Quantum Gravity (3:0),
String Theory II (3:0).

All the electives may not be offered every year. The students haveto choose the electives in consultation with their supervisors.The supervisor may ask the students to take more electives thanthe list above, even after the Comprehensive Exam, as per his/herneeds and interests.There is no provision for skipping courses, but a student may seek exemption from any course by passing a written test at the beginning of the term.

Some of the courses overlap with those of the Physics department. The CHEP specific courses are: Nuclear and Particle Physics, Quantum Mechanics III, Quantum Field Theory I and II, Advanced Mathematical Physics, General Relativity, Quantum Computation, String Theory and II, The Standard Model of Particle Physics, Experimental High Energy Physics, and Collider Physics. The syllabi for these courses appear below.

There will be a Comprehensive Exam, which the students must take as soon as possible after passing the above courses. In any case, they must take the exam before the end of their second year. The exam will test whether the student has sufficient preparation to begin Ph.D. research. Those who fail the exam will be given another attempt after a few months. At the time of joining, each student must find a provisional Faculty Advisor, who may not turn out to be the actual Ph.D. supervisor. The student must select the Ph.D. supervisor by the end of the second semester. Students will be permitted to work with a faculty outside CHEP if their research interests so demand. In such cases, however, they must have a joint supervisor in CHEP. Beginning from the second year, students must present a seminar each year on their work, to acquaint the CHEP faculty with their progress.

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.,RithK.,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.

HE 391 (AUG) 3:0

Quantum Mechanics III

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

Apoorva Patel

References :

- (1) Feynman R.P. and Hibbs A.R., Quantum Mechanics and Path Integrals, McGraw-Hill, 1965. (2) Bjorken J.D. and Drell S., Relativistic Quantum Mechanics, McGraw-Hill, 1965. (3) Greiner W., Relativistic Quantum Mechanics: Wave Equations (Third edition), Springer, 1990. (4) Peskin M.E. and Schroeder D.V., An Introduction to Quantum Field Theory, Addison Wesley, 1995.

Pre-requisites :

- Quantum Mechanics I (PH 201) and Quantum Mechanics II (PH 203), or equivalent

HE 395 (AUG) 3:0

Quantum Field Theory I

Scalar, spinor and vector fields. Canonical quantisation, propagators. Symmetries and Noether theorem. Path integrals for bosonic and fermionic fields, generating functionals. Feynman diagrams. 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.

Aninda Sinha

References :

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

Pre-requisites :

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

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 392 (JAN) 3:0

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.

BiplobBhattacherjee

References :

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

Pre-requisites :

• Quantum Field Theory I

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 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.

Chethan Krishnan

References :

• Landau L.D. and LifshitzE.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 followingtechnical areas identified by the following codes which appear as prefixes to the course numbers.

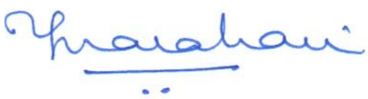
E0	Computer Science and Engineering
E1	Intelligent Systems and Automation
E2	Communication Systems
E3	Electronic Devices, Circuits and Technology
E4	Power and Energy Systems
E5	High Voltage and Insulation Engineering
E6	Power Electronics and Drives
E7	Photonic Devices, Circuits and Systems
E8	Electromagnetic,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

All the departments in the Division provide facilities for researchleading to the PhD 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)

The dissertation projects in the above M Tech. programs will be numbered as EE 299, CN 299, CS 299, ES 299, Ai 299, SP 299, and MV 299, respectively.

We wish all the students a lively and an intellectually rewarding experience in the Division of EECS at the Indian Institute of Science.



Prof. Y Narahari
Dean, Division of EECS

Department of Computer Science and Automation
October – January 2020

POOL COURSES

Course code	Title	Credits	Pool	Course type
E0 206	Theorist's Toolkit	3:1	A	Soft core
E0 224	Computational Complexity Theory	3:1	A	Soft core
E0 225	Design and Analysis of Algorithms	3:1	A	Soft core
E0 226	Linear Algebra and Probability	3:1	C	Soft core
E0 230	Computational Methods of Optimization	3:1	C	Soft core
E0 235	Cryptography	3:1	A	Soft core
E0 243	High Performance Computer Architecture	3:1	B	Soft core
E0 254	Network and Distributed Systems Security	3:1	B	Soft core
E0 256	Theory and Practice of Computer Systems Security	3:1	B	Soft core
E0 267	Soft Computing	3:1	C	Soft core
E0 271	Graphics and Visualization	3:1	B	Soft core
E0 302	Topics in Software Engineering	3:1		Elective
E0 311	Topics in Combinatorics	3:1		Elective
E0 334	Deep Learning for Natural Language Processing	3:1		Elective
E0 337	Topics in Advanced Cryptography	3:1		Elective
E0 361	Topics in Database Systems	3:1		Elective
E1 396	Topics in Stochastic Approximation Algorithms	3:1		Elective

Pool Course: October – January – 2020

Pool A

Course Number	Title	Credits
E0 206	Theorist's Toolkit	3:1
E0 224	Computational Complexity Theory	3:1
E0 225	Design and Analysis of Algorithms	3:1
E0 235	Cryptography	3:1

Pool B

Course Number	Title	Credits
E0 243	High Performance Computer Architecture	3:1
E0 254	Network and Distributed Systems Security	3:1
E0 256	Theory and Practice of Computer Systems Security	3:1
E0 271	Graphics and Visualization	3:1

Pool C

Course Number	Title	Credits
E0 226	Linear Algebra and Probability	3:1
E0 230	Computational Methods of Optimization	3:1
E0 267	Soft Computing	3:1
CP 214	Foundations of Robotics	3:1

February – May 2021

Course code	Title	Credits	Pool	Course type
E0 202	Automate Software Engineering with Machine Learning	3:1	B	Soft core
E0 205	Mathematical Logic and Theorem Proving	3:1	A	Soft core
E0 207	Computational Topology: Theory and Applications	3:1	A	Soft core
E0 208	Computational Geometry	3:1	A	Soft core
E0 209	Principles of Distributed Software	3:1	B	Soft core
E0 210	Dynamic Program Analysis: Algorithms and Tools	3:1	B	Soft core
E0 234	Introduction to Randomized Algorithms	3:1	A	Soft core
E0 238	Intelligent Agents	3:1	C	Soft core
E0 248	Theoretical Foundations of Cryptography	3:1	A	Soft core
E0 253	Operating Systems	3:1	B	Soft core
E0 255	Compiler Design	3:1	B	Soft core
E0 264	Distributed Computing Systems	3:1	B	Soft core
E0 261	Database Management Systems	3:1	B	Soft core
E0 270	Machine Learning	3:1	C	Soft core
E0 313	Theory of convex optimization and sampling	3:1		Elective
E0 314	Proof systems in Cryptography	3:1		Elective
E0 309	Topics in Complexity Theory	3:1		Elective
E0 320	Topics in Graph Theory	3:1		Elective
E0 343	Topics in Computer Architecture	3:1		Elective
E1 277	Reinforcement Learning	3:1	C	Soft core
E1 254	Game Theory	3:1	C	Soft core
E1 399	**Research in Computer Science**	1:2		Elective

Pool Course:February – May: 2021

Pool A

Course Number	Title	Credits
E0 205	Mathematical Logic and Theorem Proving	3:1
E0 207	Computational Topology: Theory and Applications	3:1
E0 208	Computational Geometry	3:1
E0 234	Introduction to Randomized Algorithms	3:1
E0 248	Theoretical Foundations of Cryptography	3:1

Pool B

Course Number	Title	Credits
E0 202	Automate Software Engineering with Machine Learning	3:1
E0 209	Principles of Distributed Software	3:1
E0 210	Dynamic Program Analysis: Algorithms and Tools	3:1
E0 253	Operating Systems	3:1
E0 255	Compiler Design	3:1
E0 264	Distributed Computing Systems	3:1
E0 261	Database Management Systems	3:1

Pool C

Course Number	Title	Credits
E0 238	Intelligent Agents	3:1
E0 270	Machine Learning	3:1
E1 277	Reinforcement Learning	3:1
E1 254	Game Theory	3:1

Dept of Computer Science and Automation

E0 206 (AUG) 3:1

Theorist's Toolkit

Motivation and objectives of the course: This course is intended to equip a student interested in studying theoretical computer science with some of the fundamental tools commonly used in this area. Tentative Syllabus: The topics covered are likely to be a subset of the following. a. Probabilistic methods: Linearity of expectations, alterations, second moment, Lovasz local lemma, martingales, random graphs, JohnsonLindenstrauss lemma, etc. b. Streaming algorithms: Hash functions, pairwise independence, heavy hitters in data stream, p-stable distributions, counting distinct elements, etc. c. Information theory: Shearer's Lemma, entropy and compression, Pinsker's lemma, KL-divergence, application in bandits and streaming algorithms, etc. d. Linear algebra based algorithms: Courant-Fischer Theorem, SVD, Cheeger's Inequality, expanders, etc. e. Discrete Fourier analysis: Boolean function and Fourier expansion, applications in property testing, etc. f. Multiplicative weights update: Hedge algorithm, applications in packing/covering LPs, online convex optimization, etc. g. Combinatorial optimization: Farkas lemma, matroids, total unimodularity, total dual integrality, etc.

Anand Louis, Arindam Khan

References :

- References: Since this is a “toolkit” course, we will be teaching material from multiple books/sources. Some of them are the following.
- a. Michael Mitzenmacher and Eli Upfal. Probability and computing: Randomization and probabilistic techniques in algorithms and data analysis. Cambridge university press, 2017.
- b. Ryan O'Donnell. Analysis of boolean functions. Cambridge University Press, 2014.
- c. Alexander Schrijver. Combinatorial optimization: polyhedra and efficiency, 2003. d. Alexander Schrijver. Theory of linear and integer programming. John Wiley & Sons, 1998.
- e.Avrim Blum, John Hopcroft, and Ravindran Kannan. Foundations of Data Science.
- f. Sanjeev Arora, Elad Hazan, and Satyen Kale. "The multiplicative weights update method: a meta-algorithm and applications." Theory of Computing 8.1 (2012): 121-164
- g. Thomas M. Cover and Joy A. Thomas. Elements of information theory. John Wiley & Sons, 2012.
- h. S. Muthukrishnan. Data streams: Algorithms and applications. Now Publishers Inc, 2005.
- i. Various surveys and lecture notes.

Pre-requisites :

- Students should have completed or also be registered for E0 225 (Design and Analysis of Algorithms).

E0 224 (AUG) 3:1

Computational Complexity Theory

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

Chandan Saha

References :

- The book titled `Computational Complexity – A Modern Approach’ by Sanjeev Arora and Boaz Barak.
- Lecture notes of similar courses as and when required.

Pre-requisites :

- Basic familiarity with undergraduate level theory of computation and data structures & algorithms would be helpful.
- More importantly, some mathematical maturity with an inclination towards theoretical computer science.

E0 225 (AUG) 3:1

Design and Analysis of Algorithms

Greedy algorithms, divide and conquer strategies, dynamic programming, max flow algorithms and applications, randomized algorithms, linear programming algorithms and applications, NP-hardness, approximation algorithms, streaming algorithms. References: Kleinberg and Tardos, Algorithm Design, Addison Wesley, 2005. Cormen, Leiserson, Rivest, and Stein, Introduction to Algorithms, 3rd Edition, Prentice Hall, 2009.

Siddharth Barman, Rahul Saladi

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.

GuganThoppe, Shirish KrishnajiShevade

References :

- Gilbert Strang, Linear Algebra and its Applications, Thomson-Brooks/ Cole, 4th edition, 2006.
- Hoffman and Kunze, Linear Algebra, Prentice Hall, 2nd edition, 1971.
- Kishor S. Trivedi, Probability and Statistics with Reliability, Queueing, and Computer Science Applications, Wiley, 2nd edition, 2008.
- Vijay K. Rohatgi, A. K. Md. Ehsanes Saleh, An Introduction to Probability and Statistics, Wiley, 2nd edition, 2000.
- Kai Lai Chung, Farid Aitsahlia, Elementary Probability Theory, Springer, 4th edition, 2006.

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

Arpita Patra, Chaya Ganesh

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.

Govindarajan R, ArkapravaBasu

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 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.

Ramesh Chandra Hansdah

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.

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.
- DaveShreiner, 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 302 (AUG) 3:1

Topics in Software Engineering

Course objective: Study and design of machine learning techniques to improve software engineering. Motivation: Machine learning has become an effective technique for making sense of large datasets to glean actionable insights. Large software repositories such as open source gits, smartphone app stores and student submissions in MOOCs courses contain a wealth of information. The goal of this course is to study and design state-of-the-art machine learning techniques to improve software engineering using the large amount of code available. Syllabus: Machine learning models for program analysis, automated program repair, program synthesis, mining software repositories, representation and deep learning for software engineering, programming language processing.

Shirish KrishnajiShevade, Aditya Sunil Kanade

References :
- Research papers

Pre-requisites :
- Background in programming
- Data mining or machine learning course in CSA

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.
- StasysJukna: Extremal Combinatorics with applications in computer science, Springer.

Pre-requisites :
- Basic familiarity with probability theory, linear algebra, and graph theory and combinatorics.

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 ,YoshuaBengio and Aaron Courville. Deep Learning. MIT Press, 2016 Recent Literature.

Shirish KrishnajiShevade

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 361 (AUG) 3:1

Topics in Database Systems

Object-oriented Databases, Distributed and Parallel Databases, Multi-databases, Access Methods, Transaction Management, Query Processing, Deductive Databases, multimedia Databases, Real- Time Databases, Active Databases, Temporal Databases, Mobile Databases, Database Benchmarks, Database Security, Data Mining and Data Warehousing. References: Readings in Database Systems edited by M. Stonebraker, Morgan Kaufmann, 2nd ed., 1994. Conference and Journal papers

Jayant R Haritsa

E1 396 (AUG) 3:1

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.

GuganThoppe, Shalabh Bhatnagar

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 :
- A basic course on probability theory and stochastic processes

E0 202 (JAN) 3:1

Automated Software Engineering with Machine Learning

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

Aditya Sunil Kanade

References :
- ZigurdMednieks and Laird Dornin and G. Blake Meike and Masumi Nakamura. Programming Android. O'Reilly, 2011.
- David Harman. Effective JavaScript. Addison-Wesley, 2012.
- SteveSouders. Even Faster Websites. O'Reilly, 2009.

- Ian Goodfellow and YoshuaBengio and Aaron Courville. Deep Learning. MIT Press, 2016.
- Research papers

E0 205 (JAN) 3:1

Mathematical Logic and Theorem Proving

Motivation and objectives of the course: This course is about mathematical logic with a focus on automated reasoning techniques that are useful in reasoning about programs. In the first part of the course we cover Propositional and First-Order logic and some of the classical results like sound and complete proof systems, compactness, and decidability of the satisfiability/validity problems. In the second part we focus on decision procedures for various theories that arise while reasoning about assertions in programs. Syllabus: Zeroth-Order/Propositional Logic: - Proofs in arithmetic - Propositional logic, proof systems - Decision procedure, completeness and compactness First-Order Logic: - Proof systems - Undecidability - Completeness and compactness Theories and Decision Procedures: - Equality and Uninterpreted Functions (EUF) - Linear Arithmetic - Array logics - Nelson-Oppen combination

Kamal Lodaya, Deepak DSouza

References :

- First-order Logic and automated theorem proving, Melvin Fitting, Springer-Verlag, 1990.
- Logic for Computer Science -- Foundations for Automatic Theorem Proving, Jean H. Gallier.
- Computability and logic, George Boolos, John Burgess and Richard Jeffrey, Cambridge U Press, 2007.
- Decision Procedures, Kroening and Strichman, Springer 2008.
- An Introduction to Logic, Madhavan Mukund and S P Suresh, Lecture Notes, Chennai Mathematical Institute (2011).

Pre-requisites :

- None.

E0 207 (JAN) 3:1

Computational Topology: Theory and Applications

1. Introduction to topological data analysis via recent applications 2. Mathematical preliminaries from group theory and linear algebra: group homomorphism and isomorphism, quotient group, classification of finitely generated Abelian groups, linear transformations, matrix representations 3. Complexes: Clique, Delaunay, Cech, Rips, random complexes, algorithms for constructing complexes 4. Simplicial homology: chains, cycles, the boundary operator, the homology group, simplicial maps, Betti numbers, Euler-Poincare characteristic, nerve theorem, matrix reduction algorithms 5. Persistent Homology: filtrations, persistence diagrams, barcodes, spanning acycles, algorithms 6. Morse functions: Morse Lemma, Morse-Smale complex, contour tree, Reeb graph, algorithms for construction and simplification, hierarchical representation 7. Random topology: Random complexes, Morse inequalities, Limiting distribution of Betti numbers and persistence diagrams 8. Software: TDA on R, Gudhi, Ripser, Javaplex, TTK

GuganThoppe, Vijay Natarajan

References :

- Edelsbrunner, Herbert, and John Harer. Computational topology: an introduction. American Mathematical Soc., 2010.
- Hatcher, Allen. Algebraic topology., (2001).
- Current Literature

Pre-requisites :

- Undergraduate Probability and Linear Algebra, E0 225: Design and Analysis of Algorithms

E0 208 (JAN) 3:1

Computational Geometry

Motivation and objective of the course: Computational Geometry is an area of computer science that looks at the computational aspects of geometric problems such as running time of an algorithm, space occupied by a data structure, design of polynomial time approximation algorithms. This area has been well studied over the last four decades and has found applications in computer graphics, computer-aided design, geographic information systems, robotics, etc. This course will focus on the theoretical aspects of algorithms and data structures for various geometric problems. Syllabus: The list of topics covered in this course include a. Convex hulls: 2-D and higher dimensional convex hulls, output sensitive algorithms, randomized incremental construction b. Intersection detection: Segment intersection, plane sweep technique. c. Geometric data structures for range searching and point location: Segment and interval trees, range trees, kd-tree, persistence. d. Proximity problems: Voronoi diagram, Delaunay triangulation, well separated pair decomposition, locality sensitive hashing. e. Arrangements: Arrangements of lines and hyperplanes, sweep-line and incremental algorithms, lower envelopes, levels, zones. f. Geometric sampling: Random sampling and epsilon-nets, epsilon-approximation and discrepancy, coresets. g. Geometric optimization: Linear programming, geometric set cover, geometric independent set, clustering.

Rahul Saladi, Sathish Govindarajan

References :

- [Main textbook] M. de Berg, O. Cheong, M. van Kreveld, and M. Overmars, Computational Geometry: Algorithms and Applications. Springer-Verlag, 3rd ed., 2008.
- Lecture notes on Computational Geometry by David Mount: https://www.cs.umd.edu/class/spring2012/cmsc754/Lects/cmsc754-lects.pdf
- [Additional reference] Sariel Har-Peled. Geometric Approximation Algorithms (Mathematical Surveys and Monographs). American Mathematical Society (2011).

Pre-requisites :

- E0 225: Design and Analysis of Algorithms

E0 209 (JAN) 3:1

Principles of Distributed Software

Motivation and objectives of the course : Development of distributed software applications is a very important activity, accelerated in recent years by the increasing predominance of cloud computing. The typical requirements from a modern day distributed application are continuous availability even in the presence of software and hardware faults, ability to scale up or down on-the-fly based on input load (i.e., elasticity), ease of development and maintenance, and ease of continuous integration and deployment. This course will introduce the principles and programming models and frameworks for distributed applications that help meet these requirements. It will also cover representative modern languages and technologies that are used to develop and deploy such applications. Syllabus : Main features of cloud applications, such as availability, fault tolerance, elasticity, and microservices. The challenges in building cloud applications. Introduction to different types of concurrent and distributed programming models. Introduction to actors -- a message-driven programming model that enables large scale concurrency, distribution, and fault tolerance. Programming actor-based systems using the Akka toolkit. Achieving availability and elasticity by distributing the application over multiple nodes using Akka Cluster. Using Kubernetes to deploy, scale, and monitor distributed applications. Consistency of data in distributed programs, eventual consistency, and implementing these features using Conflict-free Replicated Data Types in Akka. Practical application of these principles in a substantial course project.

Raghavan K V

References :

- Distributed and Cloud Computing, by K. Hwang, G. C. Fox, and J. J. Dongarra, Morgan Kaufmann Publishing, 2012
- Designing Distributed Systems, by Brendan Burns, O'Reilly, 2018
- Online documentation for Akka and Kubernetes
- Selected research papers
- https://azure.microsoft.com/en-us/resources/designing-distributed-systems/ https://www.amazon.in/Designing-Distributed-Systems-Patterns-Paradigms-ebook/dp/B079YTM4FC

Pre-requisites :

- Under-graduate level data structures and algorithms. Programming experience required, preferably in Java.

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 234 (JAN) 3:1

Introduction to Randomized Algorithms

Motivation and objectives of the course : The use of randomness in algorithm design is an extremely powerful paradigm. Often, it makes algorithm design (and analysis) easier; however, there are some problems for which we only know randomized algorithms and no deterministic algorithms. Furthermore, depending on the model of computation, randomization is often essential — it provably does better than all deterministic algorithms. In this course, we will introduce the basic techniques of designing randomized algorithms although at times we will dive into state-of-the-art topics. Students are expected to have taken an introductory course in algorithm design and analysis, and some familiarity with probability, although not essential, is desirable. Syllabus: Basics of probability, events, discrete random variables, expectation, moments, deviations, Chernoff and Hoefding bounds, balls and bins, random graphs, probabilistic methods, Markov chains and random walk, Monte Carlo method, coupling, martingales, sample complexity, VC dimension, Rademacher complexity, balanced allocation, power of two choices, cuckoo hashing, information and entropy, online algorithms, random-order model, streaming algorithms.

Siddharth Barman, Arindam Khan

References :
- Probability and Computing" by Mitzenmacher and Upfal
- Randomized Algorithms" by Motwani and Raghavan.

Pre-requisites :
- E0 225 (Design and Analysis of Algorithms) and E0 226 (Linear Algebra and Probability).

E0 238 (JAN) 3:1

Intelligent Agents

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

Susheela Devi V

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

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 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. UreshVahalia: 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, ArkapravaBasu

References :

- Andrew S. Tanenbaum: Modern Operating Systems, Second Edition, Pearson Education, Inc., 2001.
- UreshVahalia: 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.

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.

Govindarajan R, Uday Kumar Reddy B

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.

Ramesh Chandra Hansdah

References :

- Randy Chow, and Theodore Johnson, “Distributed Operating Systems and Algorithms”, Addison-Wesley, 1997.
- Randy Chow, and Theodore Johnson, “Distributed Operating Systems and Algorithms”, Addison-Wesley, 1997.
- 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

Pre-requisites :

- NDSS(E0 254) or equivalent course

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.

Ambedkar Dukkipati, Chiranjib Bhattacharyya

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 309 (JAN) 3:1

Topics in complexity theory

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

Chandan Saha

References :
- Current literature on Arithmetic circuit complexity.

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

E0 313 (JAN) 3:1

Theory of convex optimization and sampling

Motivation and objectives of the course: This course is intended to teach students in theoretical computer science and related areas about the theory of convex optimization. Our goal is that at the end of the course, students should know some of the common algorithmic techniques used for optimizing convex functions and sampling from convex bodies. Tentative Syllabus: The topics covered are likely to be a subset of the following. a. Introduction to Gradient descent and cousins: Basics of convex functions, gradient descent, accelerated gradient descent, stochastic gradient descent, mirror descent and other variants. b. Cutting plane methods: Center of gravity, Ellipsoid algorithm, recent breakthroughs on improved running times. c. Interior point methods: Newton’s method, theory of self-concordant functions, polynomial time algorithm for linear programming, recent breakthroughs on improved running times. d. Sampling from convex bodies: Basics of Markov Chains, Isoperimetric inequalities, Ball walk, Dikin walk, Hamiltonian Monte Carlo. e. Connections to combinatorial optimization: Graph sparsification, Laplacian system solvers, faster algorithms for max flow.

Anand Louis

References :

- We will be teaching the material from multiple courses/books. Some of them are the following.
- Yin Tat Lee and Santosh Vempala. Theory of Optimization and Continuous Algorithms. 2019.
- NisheethVishnoi. Algorithms for convex optimization. 2018.
- SebastienBubeck. Convex Optimization: Algorithms and Complexity, Foundations and Trends in Machine Learning. 2015.

Pre-requisites :

- E0 225 (Design and Analysis of Algorithms)

E0 314 (JAN) 3:1

Proof Systems in Cryptography

The course is intended to introduce cryptographic proof systems and applications to students studying cryptography. Syllabus : The tentative topics that will be covered: *Interactive proofs: Class IP, IP=PSPACE Sumcheck protocol, doubly efficient proofs Delegating computation, interactive proofs for muggles Zero-knowledge (ZK) proofs * Foundations of ZK: ZK for NP, motivation and definitions Round complexity, Non-black-box Zero-knowledge Sequential and Parallel composition Limitations and lower bounds, Witness indistinguishability * More ZK: Honest verifier zero-knowledge Malicious verifier zero-knowledge, proof of knowledge, zero-knowledge arguments Sigma protocols, Non-interactive ZK, Groth-Sahai proof system MPC and zero-knowledge, MPC-in-the head * SNARKs (Succinct Non-interactive ARguments of Knowledge): PCP, Succinct arguments, separation from falsifiable assumptions Preprocessing SNARKs with trusted setup SNARKs from linear PCP Polynomial commitments, universal updatable SNARK, holographic proofs * Interactive Oracle Proof (IOP): Model and definitions IP,PCP as a special case of IOP Applications of IOP in delegation of computation Transparent SNARKs * Recent developments: Confidential transactions, Anonymous cryptocurrency like ZCash Recursive composition theorem for SNARK, Proof-carrying data Applications in succinct blockchain, Decentralized private computation, Research directions

Arpita Patra, Chaya Ganesh

References :

- There will be multiple sources. Since this is an advanced course, references for most of the material will be research papers and surveys.
- Foundations of Cryptography, Parts I and II, Oded Goldreich
- Efficient Secure Two-Party Protocols -- Techniques and Constructions, Carmit Hazay and Yehuda Lindell.
- Computational Complexity, Barak and Arora
- Surveys by Oded Goldreich on doubly efficient proofs and PCP

Pre-requisites :

- Algorithms, Intro to crypto

E0 320 (JAN) 3:1

Topics in Graph Theory

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

Sunil Chandran L

References :

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

E0 343 (JAN) 3:1

Topics in Computer Architecture

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

ArkapravaBasu

Pre-requisites :
- Computer Architecture, Operating Systems, Some Familiarity with Analytical Performance Evaluation Techniques.

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 KrishnajiShevade, 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, RamasuriNarayanam, Hastagiri Prakash. Game Theoretic Problems in Network Economics and Mechanism Design Solutions. Springer, 2009.

Siddharth Barman, Narahari Y

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.

GuganThoppe, Shalabh Bhatnagar

EP 299 (JAN) 0:24

Project

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

Satish L, Chandramani Kishore Singh, ArkapravaBasu, Ambedkar Dukkipati, Aditya Sunil Kanade, Navin Kashyap, Mayank Shrivastava

Dept.of Electrical Communication Engineering

M.Tech. Communication and Networks(M.Tech.(C & N))

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 gives the students the option to graduate with one of 5 “Minors”:

(i) Minor in Integrated Circuits & Systems,
(ii) Minor in Photonics,
(iii) Minor in Radio-Frequency Systems
(iv) Minor in Signal Processing
(v) Minor in Artificial Intelligence

(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 Minor area.

(d) This basket of courses is further divided into two or three pools, Pool X, Pool Y and Pool Z (only for Minor in Artificial Intelligence), and a student is required to take a total of 3 courses from all pools combined with

(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.
(iii) at least one course from each of the three pools X, Y, and Z, in the case of a Minor in Artificial Intelligence.

(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 205 (AUG) 3:0 Error-Control Coding
E2 223 (AUG) 3:0 Communication Protocols
E2 242 (JAN) 3:0 Multiuser Detection
E2 204 (JAN) 3:0 Stochastic Processes and Queueing Theory
E2 203 (JAN) 3:0 Wireless Communication
E2 241 (JAN) 3:0 Wireless Networks

Pool B (in no particular order)
E0 259 (AUG) 3:1 Data Analytics
E0 251 (AUG) 3:1 Data Structures & Algorithms
E1 251 (AUG) 3:0 Linear and Nonlinear Optimization
E2 212 (AUG) 3:0 Matrix Theory
E9 201 (AUG) 3:0 Digital Signal Processing
E1 254 (AUG/JAN) 3:1 Game Theory
E9 211 (JAN) 3:0 Adaptive Signal Processing
E7 221 (JAN) 2:1 Fiber – Optic Communication

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 Xwill 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
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

Pool Y
E7 211 (JAN) 3:0 Photonics Integrated Circuits

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 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
E9 211 (JAN) 3:0 Adaptive Signal Processing
E9 212 (JAN) 3:0 Spectrum Analysis
E9 213 (JAN) 3:0 Time-Frequency Analysis
E9 221 (AUG) 3:0 Signal Quantization and Compression

Pool Y
E1 213 (JAN) 3:1 Pattern Recognition and Neural Networks
E1 216 (JAN) 3:1 Computer Vision
E9 203 (JAN) 3:0 Compressed Sensing and Sparse Signal Processing
E9 262 (JAN) 3:0 Stochastic Models for Language, Speech and Audio
E9 231 (JAN) 3:0 MIMO 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

E. **Minor in Artificial Intelligence**

Requirements:

- Any 3 of the courses listed below under Pools X, Y & Z
- One course from each pool will qualify a student for a “Minor in Artificial Intelligence’’

Pool X
E1 213 (JAN) 3:1 Pattern Recognition and Neural Networks
E0 270 (JAN) 3:1 Machine Learning
E2 236 (JAN) 3:1 Foundations of Machine Learning

Pool Y
E0 230 (AUG) 3:1 Computational Methods of Optimization
E0 265 (JAN) 3:1 Convex Optimization and Applications
E0 299 (AUG) 3:1 Computational Linear Algebra
E0 251 (AUG) 3:1 Data Structures and Algorithms
E1 245 (AUG) 3:0 Online Prediction and Learning

Pool Z
E0 251 (AUG) 3:1 Data Analytics
E0 268 (JAN) 3:1 Practical Data Science
E1 246 (JAN) 3:1 Natural Language Understanding
E0 334 (AUG) 3:1 Deep Learning for NLP
E9 205 (AUG) 3:1 Machine Learning for SP
DS 222 (AUG) 3:1 ML for Large Data Sets
DS 265 3:1 (JAN) Deep Learning for Computer Vision
E0 306 (JAN) 3:1 Deep Learning: Theory and Practice
E9 253 (JAN) 3:0 Neural Networks and Learning Systems

Project 28 Credits

CN 299 0:28 Dissertation Project

Electives: The balance of credits to make up the minimum of 64 credits required for completing the M.Tech. Programme (all at 200 level or higher) from within/outside the department to be taken with the approval of the Faculty advisor/DCC.

Departments of Electrical Engineering and Electrical Communication Engineering
MTech Degree in Signal Processing

(Duration 2 years)
COURSE STRUCTURE: 64 Credits (36 Credits course work + 28 Credits project)

Hard Core **(12 Credits)** (**All courses compulsory**)			
Jan	E1 244	3:0	Detection and Estimation Theory
Aug	E1 251	3:0	Linear and Nonlinear Optimization
Aug	E2 202	3:0	Random Processes
Aug	E2 212	3:0	Matrix Theory

Soft Core **(Minimum of 12 Credits)**			
Jan	E1 213	3:1	Pattern Recognition and Neural Networks
Jan	E1 216	3:1	Computer Vision
Aug	E2 211	3:0	Digital Communication
Aug	E9 211	3:0	Adaptive Signal Processing
Jan	E9 213	3:0	Time-Frequency Analysis
Aug	E9 221	3:0	Signal Quantization and Compression
Jan	E9 231	3:0	MIMO Signal Processing
Aug	E9 241	2:1	Digital Image Processing
Jan	E9 261	3:1	Speech Information Processing
Aug	E9 291	2:1	DSP System Design

Project: 28 Credits
SP 299 0:28 Dissertation Project

Electives: The balance of 12 credits to make up the minimum of 64 credits required to complete the MTech degree must be obtained through electives (all at 200 level or higher) from within/outside the EE and ECE departments, taken with the approval of the Faculty advisor/DCC.

Departments of Electronic Systems Engineering and Electrical Communication Engineering

MTech Microelectronics and VLSI Design

Duration: 2 Years **Credits: 64**			**Total**
Core Courses: 18 credits, mandatory for all students.			
E0 284	2:1	Aug	Digital VLSI Circuit
E3 200	1:2	Jan	Microelectronics Lab
E3 220	3:0	Aug	Foundations of Nanoelectronics Devices
E3 231	2:1	Jan	Digital Systems Design with FPGAs
E3 238	2:1	Aug	Analog VLSI Circuits
E3 282	3:0	Jan	Basics of Semiconductor Devices and Technology
Electives: 18 credits (all at 200 level or higher). 1. Students can choose any course from the offered list across the institute. Following courses, listed in the Scheme of Instructions, are merely suggestions. **2.** Crediting two course having similar syllabus/content is strictly discouraged			
E1 201	2:1	Jan	Hardware Acceleration and Optimization for Machine Learning
E3 225	3:0	Aug	Art of Compact Modelling
E3 237	3:0	Jan	Integrated Circuits for Wireless Communication
E3 245	2:1	Aug	Processor System Design
E3 271	1:2	Jan	Reliability of Nanoscale Circuits and Systems
E3 274	1:2	Jan	Design of Power Semiconductor Devices
E3 275	2:1	Jan	Physics and Design of Transistors
E3 280	3:0	Jan	Carrier Transport in Nanoelectronics Devices
E3 301	3:0	Jan	Special topics in Nanoelectronics
E7 211	2:1	Jan	Photonic Integrated Circuits
E7 214	3:0	Jan	Optoelectronic Devices
E8 202	2:1	Aug	Computational Electromagnetics
E8 242	2:1	Jan	RF IC and Systems
E8 262	3:0	Jan	CAD for High Speed Chip-Package-Systems
NE 203	3:0	Aug	Advanced Micro and Nano Fabrication Technology and Process
NE 205	3:0	Aug	Semiconductor Devices and Integrated Circuit Technology
NE 215	3:0	Aug	Applied Solid State Physics
NE 222	3:0	Aug	MEMS: Modeling, Design, and Implementation
NE 241	3:0	Aug	Material Synthesis: Quantum Dots to Bulk Crystals
NE 202	0:1	Jan	Device Fabrication Lab Module (Micro and Nano Fabrication)

NE 201	2:1	Jan	Micro and Nano Characterization Methods
NE 314	3:0	Jan	Semiconductor Opto-electronics and Photovoltaics
NE 221	2:1	Jan	Advanced MEMS Packaging Lab: Packaging Lab
IN 221	3:0	Aug	Sensors and Transducers
IN 229	3:0	Aug	Advanced Instrumentation Electronics
IN 212	3:0	Jan	Advanced Nano/Micro Systems
IN 214	3:0	Jan	Semiconductor Devices and Circuits
IN 224	3:0	Jan	Nanoscience and Device Fabrication
MT 209	3:0	Aug	Defects in Materials
MT 213	3:0	Jan	Electronic Properties of Materials
E3 257	2:1	Jan	Embedded System Design
E3 276	2:1	Jan	Process Tech & System Eng for Adv Microsensors and Devices
PH 203	3:0	Aug	Quantum Mechanics-I
PH 208	3:0	Jan	Condensed Matter Physics-I
PH 352	3:0	Jan	Semiconductor Physics
PH 359	3:0	Jan	Physics at Nanoscale
MR 303	3:0	Aug	Nanomaterials Synthesis and Devices
MR 307	3:0	Jan	Thin Film, Nano Materials and Devices: Science and Engineering
MR 308	2:1	Jan	Computational Modeling of Materials
Project: 28 Credits			
MV 299	00:28		Dissertation Project

Electrical Communication Engineering

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

E2 201 (AUG) 3:0

Information Theory

Measures of information and their properties: entropy, mutual information, Kullback-Leibler divergence, total variation distance; information theoretic lower bounds, data compression, channel codes and channel capacity

Himanshu Tyagi

References :
- T. M. Cover and J. A. Thomas, Elements of Information Theory, 2nd edition, John Wiley & Sons
- I. Csiszar and J. K orner, Information Theory: Coding Theorems for Discrete Memoryless Systems, 2nd edition, Cambridge University Press
- T. S. Han, Information spectrum methods in Information Theory, Stochastic Modeling and Applied Probability series, Springer

Pre-requisites :
- Undergraduate level probability

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, Markov inequality. 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. The Poisson process.

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.
- Probability and Random Processes: With Applications to Signal Processing and Communications, Scott L. Miller and Donald G. Childers, 2nd Edition, 2012.

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, cyclic codes; polar codes and Reed-Muller codes.

Navin Kashyap, Vijay Kumar P

References :

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

E2 206 (AUG) 3:0

Quantum Information Theory

Syllabus: Review of Linear algebra, Quantum axioms, Quantum gates, basic Quantum algorithms, Quantum entanglement, Quantum error correction codes. Quantum channels, State and channel distance measures. Quantum entropy, source coding. Quantum channel capacity: classical capacity of quantum channels, entanglement-assisted classical capacity. Quantum information over quantum channel. Quantum capacity.

Vinod Sharma

References :

- M M Wilde, From Classical to Quantum Information Theory, 2nd ed, CUP, 2016.
- M A Nielsen and I L Chuang, Quantum Computation and Quantum Information CUP, 2000.

Pre-requisites :

- A basic course in probability, matrices and linear algebra.

E2 207 (AUG) 3:0

Concentration Inequalities

Limit results and concentration bounds; Chernoff bounds: Hoeffding’s inequality, Bennett’s inequality, Bernstein’s inequality; variance bounds: Efron-Stein inequality, Poincare inequality; the entropy method and bounded difference inequalities; log-Sobolev inequalities and hypercontractivity; Talagrand's convex distance inequality; the transportation method; influences and threshold phenomena

Aditya Gopalan, Himanshu Tyagi

References :

- Stephane Boucheron, Gabor Lugosi, and Pascal Massart, ``Concentration Inequalities,” Oxford University Press, 2013.

Pre-requisites :

- A course on either probability, random processes or measure theory. Basic mathematical maturity and working familiarity with probability calculations.

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.

Chandra R Murthy

References :

- Horn and Johnson, Matrix Analysis, Second Edition, Cambridge University press, 2017
- Carl D Meyer, Matrix Analysis and Applied Linear Algebra, SIAM Publication, 2000
- Gilbert Strang, Linear Algebra and its Applications, Fourth Edition, Thomson Brooks/Cole, 2007.
- Golub, and Van Loan, Matrix Computations, Fourth Edition, John Hopkins University Press, 2015

Pre-requisites :

- Undergraduate linear algebra

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.

Rahul Singh

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, I/Q imbalance, DC offset correction, error vector magnitude (EVM), power amplifier (PA) non-linearities; impact of PA distortions in OFDM, PAPR issues, CFO estimation and correction, SFO estimation and correction. Visible light wireless communications (VLC); transmitter, channel, receiver, performance, MIMO-VLC. Deep neural networks (DNNs) in communication systems design.

Chockalingam A

References :

- Tony J. Rouphael. Wireless Receiver Architectures and Design:,Antenna, RF, Synthesizers, Mixed Signal and Digital Signal Processing. Academic Press, 2014
- LydiSmaini. RF Analog Impairments Modeling for Communication Systems Simulation: Application to OFDM-based Transceivers. John-Wiley & Sons, 2012.
- AbbasMohammadi and Fadhel M. Ghannouchi. RF Transceiver Design for MIMO Wireless Communications. Springer-Verlag, 2012.
- Research papers

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 retrieval.

Sundar Rajan B

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

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

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++).

DipanjanGope, Vinoy K J

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 208 (AUG) 3:1

Digital Video: Perception and Algorithms

Frequency response of human visual systems, color perception, video transforms, retinal and cortical filters (center-surround responses, 3D Gabor filter banks), motion detection, optical flow algorithms (Horn-Schunck, Black-Anandan, Fleet-Jepson, optical flow in the brain), block motion, supervised and unsupervised deep learning of optical flow, video compression, statistical video models (principal components, independent components, sparse coding), video quality assessment, egomotion estimation/visual odometry, deep generative and prediction models for videos.

Rajiv Soundararajan

References :

- A. C. Bovik, Al Bovik's Lecture Notes on Digital Video, The University of Texas at Austin, 2020
- M. Tekalp, Digital Video Processing, Prentice Hall, 1995

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

MV 299 (AUG) 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 a specified period and should submit the Project Report for final evaluation.

Navin Kashyap

CN 299 (JAN) 0:28

Project (M.Tech., Communication and Networks)

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

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 208 (JAN) 3:0

Topics in Information Theory and Coding

Low-Latency Codes: Streaming Codes, Fountain and Raptor codes, Gilbert-Elliott Channel, ARQ Methods, relevance to 5G..

Vijay Kumar P

References :

- From journal articles.

Pre-requisites :

- Background in Coding theory. (E2 205).

E2 209 (JAN) 3:0

Topics in Information Theory & Statistical Learning

This course will cover the basics of, and some recent advances in, the use of information theoretic techniques in statistical learning. The following topics will be covered: Hypothesis testing and minimax estimation; maximum likelihood estimation; asymptotic optimality; local asymptotic normality; sample optimal testing and estimation (uniformity testing, equality testing, independence testing, missing mass estimation, support estimation, learning Gaussian mixtures); information criteria for model selection (AIC, BIC, MDL); topics in nonparametric estimation.

Himanshu Tyagi

Pre-requisites :

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

E2 236 (JAN) 3:1

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, MehryarMohri, Afshin Rostamizadeh, and Ameet Talwalkar
- Understanding Machine Learning, Shai Shalev-Shwartz and Shai Ben-David

Pre-requisites :
- Random processes

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 RudigerUrbanke (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)

E2 334 (JAN) 3:0

Topics in Computation over Networks

Content will be a subset of the following topics: Statistical physics: Boltzmann distributions, Thermodynamic potentials and limit, Ferromagnets and Ising models Probability: Stochastic ordering, large deviations, Gibbs free energy, Monte Carlo method, simulated annealing Independence: Random energy model, random code ensemble, number partitioning, replica theory Graph models: Random factor graphs, Random K-SAT, LDPC codes Phase transitions: ErdosRenyi random graph Short-range correlations: Belief propagation, Ising models on random graphs Long range correlations: Cavity method

Parimal Parag

References :

- Information, Physics, and Computation, Mezard, Montanari
- Random graphs and complex networks, Remco van der Hofstad

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

Varun Raghunathan, Srinivas T

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 (responsitivity, gain and speed), and noise processes in detection. Light modulation: Electro-optic devices, amplitude and phase modulation, Franz-Keldysh effect, quantum confined stark effect. Review of current topics in optoelectronics: heterogeneously integrated lasers, thermo-photo voltaic devices, silicon photonics, Germanium lasers, SPASERS, Polariton lasers etc. 3-4 homeworks, one midterm, one final and a group project are intended as means of evaluating the students.

Varun Raghunathan

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.

E7 221 (JAN) 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 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

The objective of this course is to provide an exposure to fundamental numerical techniques used in modeling and simulation of high speed circuits. The course will cover: (A) Fundamental techniques: SPICE simulation fundamentals 2D Electromagnetic Analysis 2.5D Electromagnetic Analysis 3D Electromagnetic Analysis (B) Applications discussed: Signal integrity for high-speed PCB buses Power integrity for low-power applications EMI/EMC for Automotive.

DipanjanGope

References :
- Stephen H. Hall and Howard. L. Heck: Advanced Signal Integrity for High Speed Designs, 2009, IEEE Computer Society Press
- Howard W. Johnson and Martin Graham: High Speed Signal Propagation: Advanced Black Magic, 2003, Prentice Hall
- Madhavan Swaminathan and EgeEngin: Power Integrity Modeling and Design for Semiconductors and Systems, 2007, Prentice Hall

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

This course will cover concepts related to the use of multiple sensors to solve problems related to the Direction of Arrival Estimation using Sensor arrays, 5G Wireless Communication Systems, and other applications.

Hari K V S

References :
- Array Signal Processing: Concepts and Techniques by Dan E. Dudgeon and Don H. Johnson
- Detection, Estimation, and Modulation Theory, Optimum Array Processing by Harry L. Van Trees

E9 271 (JAN) 3:0

Space-Time Signal Processing and Coding

Cache-aided communication; Wireline and wireless network coding; Device-to-Device (D2D) communications; Vehicular (V2V, V2X, I2V) communications; Multi-user and Multiple-Input Multiple-Output (MIMO) communication systems; Coding and algorithms for broadcast, multicast and interference channels; Distributed Space-Time Code construction and signal processing algorithms.

Sundar Rajan B

References :

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

Pre-requisites :

- Basic course in Digital Communication

MV 299 (JAN) 0:28

Project (M.Tech., Microelectronics and VLSI Design)

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 a specified period and should submit the Project Report for final evaluation.

CN 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

Dept of Electrical Engineering

MTech Degree in Electrical Engineering
2020-2022 BATCH
(Duration 2 years)
64 Credits

COURSE STRUCTURE: 64 Credits (40 Credits course work + 24 Credits project)

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

Soft Core (Pick any FIVE out of NINE)			
1	E1 241	3:0	Dynamics of Linear Systems
2	E8201	3:0	Electromagnetism
3	E4 231	3:0	Power System Dynamics & Control
4	IN 227	3:0	Control System Design
5	E3 252	3:1	Embedded System Design for Power Application
6	E4 233	3:0	Computer Control of Power Systems
7	E5 206	3:0	HV Power Apparatus
8	E5 209	3:0	Overvoltages in Power Systems
9	E6 211	3:0	Electric Drives

Project: 24 Credits

EP 299(EE) 0:24 Dissertation Project

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

NOTE: This structure is applicable to students admitted in 2020.

MTech Degree in Signal Processing - 2020

(Duration 2 years)

COURSE STRUCTURE : 64 Credits (36 Credits course work + 28 Credits project)

Hard Core **(12 Credits)** (**All courses compulsory**)			
Jan	E1 244	3:0	Detection and Estimation Theory
Aug	E1 251	3:0	Linear and Nonlinear Optimization
Aug	E2 202	3:0	Random Processes
Aug	E2 212	3:0	Matrix Theory

Soft Core **(Minimum of 12 Credits)**			
Jan	E1 213	3:1	Pattern Recognition and Neural Networks
Jan	E1 216	3:1	Computer Vision
Aug	E2 211	3:0	Digital Communication
Aug	E9 211	3:0	Adaptive Signal Processing
Jan	E9 213	3:0	Time-Frequency Analysis
Aug	E9 221	3:0	Signal Quantization and Compression
Jan	E9 231	3:0	MIMO Signal Processing
Aug	E9 241	2:1	Digital Image Processing
Aug	E9 261	3:1	Speech Information Processing
Aug	E9 291	2:1	DSP System Design

Project: 28 Credits

EP 299(SP) 0:28 Dissertation Project - **The project code needs to changed suitably**

Electives: The balance of 12 credits to make up the minimum of 64 credits required to complete the MTech degree (all at 200 level or higher) must be obtained through electives from within/outside the EE and ECE departments, taken with the approval of the Faculty advisor/DCC.

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. Laboratory will be by using simulator

Rathna G N

References :
- WIRELESS SENSOR NETWORKS Technology, Protocols, and Applications by KAZEM SOHRABY DANIEL MINOLI TAIEB ZNATI

Pre-requisites :
- Consent of Instructor

E0 299 (AUG) 3:1

Computational Linear Algebra

Theory: Solution of linear equations, vector space, linear transformations, matrix representation, inner-products and norms, orthogonality and least-squares, trace and determinant, eigendecomposition, symmetric (Hermitian) matrices and quadratic forms, singular value decomposition. Computations: linear solvers, least squares, QR (Gram-Schmidt), SVD.

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.

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.

Vaibhav Katewa, PavankumarTallapragada

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”

E1 246 (AUG) 3:0

Topics in Networked and Distributed Control

Core topics: Relevant background topics in control, Estimation and control under communication constraints such as sampling, quantization, packet losses, time delays; data rate limited control; Consensus, synchronization, coverage control, multi-agent systems, Selected topics from: Event-triggered control, connectivity maintenance, distributed estimation, distributed optimization, distributed hypothesis testing, privacy and security in networked and distributed control systems, social networks, opinion dynamics, epidemic spread, applications in robotics and transportation

Vaibhav Katewa, PavankumarTallapragada

References :

• 1. Bemporad, Alberto, Maurice Heemels, and Mikael Johansson. Networked control systems. Vol. 406. London: Springer, 2010.
• 2. Yüksel, Serdar, and Tamer Basar. Stochastic networked control systems: Stabilization and optimization under information constraints. Springer Science & Business Media, 2013.
• 3. Mesbahi, Mehran, and Magnus Egerstedt. Graph theoretic methods in multiagent networks. Princeton University Press, 2010.
• 4. Bullo, Francesco. Lectures on Network Systems (http://motion.me.ucsb.edu/book-lns/)
• 5. Bullo, Francesco, Jorge Cortes, and Sonia Martinez. Distributed control of robotic networks: a mathematical approach to motion coordination algorithms. Princeton University Press, 2009.
• 6. Current literature

Pre-requisites :

• Some background in graduate level control and/or related areas such as linear systems theory, nonlinear systems, random processes. Permission of the instructor.

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

MuthuvelArigovindan

References :

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

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.

GurunathGurrala

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 206 (AUG) 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.

E6 211 (AUG) 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 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 226 (AUG) 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

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 241 (AUG) 2:1

Digital Image Processing

Image formation and representation, image histograms, binarization and thresholding, binary morphology, point operations, histogram equalization and matching, spatial filters, 2D Fourier transform, discrete space Fourier transform, discrete Fourier transform, sampling theorem, linear and circular convolution, Wiener filter for restoration, order statistic filters, bilateral filter, image downsampling and upsampling, edge detection, Hough transform, Haris corner detection, scale invariant feature transform, bag of words model, deep learning of image features.

Soma Biswas, Rajiv Soundararajan

References :

- R. C. Gonzalez and R. E. Woods , Digital image processing, Prentice Hall, 2008
- Richard Szeliski, Computer Vision: Algorithms and Applications, Springer, 2010
- A K Jain , Fundamentals of digital image processing, Prentice Hall, 1989
- A. C. Bovik, Al Bovik's Lecture Notes on Digital Image Processing, The University of Texas at Austin, 2019
- David A. Forsyth and Jean Ponce, Computer Vision: A Modern Approach, Pearson Education, 2003

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 MATLAB and CCS 5.4 simulator

Rathna G N

References :

- References: 1. Morrow, Michael G. Welch, Thad B. Wright, Cameron H. G - Real-Time Digital Signal Processing from MATLAB to C with the TMS320C6x DSPs, Third Edition-Chapman and Hall_CRC (2016) 2. RulphChassaing,Digital signal processing and applications with C6713 and C6416 DSK,Wiley,2005

E9 309 (AUG) 3:1

Advanced Deep Learning

Visual and Time Series Modeling: Semantic Models, Recurrent neural models and LSTM models, Encoder-decoder models, Atten-tion models. Representation Learning, Causality AndExplainability: t-SNE visualization, Hierarchical Representation, semantic embeddings, gradient and perturba-tion analysis, Topics in Explainable learning, Structural causal models. Unsupervised Learning: Restricted Boltzmann Machines, Variational Autoencoders, Generative Adversarial Networks. New Architectures: Capsule networks, End-to-end models, Transformer Networks. Applications In NLP, Speech, Image/Video domains in all modules.

Sriram Ganapathy

References :
- Research papers/tutorials in the domain, Lecture notes in pdf format.
- Deep Learning, Ian Goodfellow and YoshuaBengio and Aaron Courville, MIT Press 2016

Pre-requisites :
- Linear Algebra. Random Process.
- Basic machine learning/pattern recognition course. Good background in python programming

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,PearsonEducation,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 213 (JAN) 3:1

Pattern Recognition and Neural Networks

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

Subbayya Sastry P

Pre-requisites :

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

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.

PavankumarTallapragada

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 Microcontrollers 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 221 (JAN) 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 233 (JAN) 3:0

Computer Control of Power Systems

GurunathGurrala

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 201 (JAN) 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 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

E5 232 (JAN) 2:1

Advances in Electric Power Transmission

• Recent advances in UHV power transmission - introduction to 765/1200kV AC and ±500/800 kV DC transmission systems; present status and future growth. • Design criteria for overhead transmission lines: general system design, methodology, reliability, wind/ice loading, security and safety requirements. •

Components of HV transmission systems, types of conductors/HTLS, bundle configurations, conductor accessories/clamps etc. • Transmission towers: calculations of clearances for power frequency, switching and lightning surges, right of way (ROW), earth wire/OPGW, • Selection of insulators for light, medium and heavy polluted areas. • Up-gradation of existing transmission lines, • Design considerations of UHV Substations, Comparison of AIS, Hybrid-AIS and GIS. • Review on insulation coordination/overvoltages for UHV systems- high performance metal oxide surge arresters, Introduction to SCADA and Substation automation. • Earthing and safety measures for 765/1200kV HV substations. • Field / Industry visit – Substation / Industry • Assignment - involving computation of potential distribution, ground end electric & magnetic fields.

Subba Reddy Basappa

References :

- 1.Rakosh Das Begamudre, " Extra High Voltage AC Transmission Engineering", New Age International(P) Ltd, New Delhi, 2000.
- 2.E Kuffel, W S Zaengl and J Kuffel, "High Voltage Engg. Fundamentals", textbook published by Newness publishers, second edition, 2000.
- 3. K Papailiou and F Schmuck, "Silicone Composite Insulators: Materials, design, Applications for Power systems, Springer Berlin Heidelberg, 2012.
- 4. Outdoor Insulators", Ravi Gorur, Edward Cherney & Jeffery Burnham Text book, 1999
- 5.Insulators for High Voltage – J S T Looms, text book, Peregrines, 1988 •
- 6. Recent IEEE, CIGRE, IEC Standards and other International publications

E6 201 (JAN) 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,SorabK.Ghandhi, Semiconductor Power Devices, John Wiley and Sons, 1976

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.

E6 225 (JAN) 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

E9 205 (JAN) 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 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 system and signal analysis: short-time Fourier transform; Spectrogram and Applications - pitch and time scale modification; Quasi-stationary analysis: cepstrum, Mel frequency cepstral coefficients; AM-FM, sinusoidal models for speech; Linear Prediction, AR and ARMA modeling of speech; Sequence Modeling of Speech - Dynamic Time Warping, Introduction to Hidden Markov Models; Deep learning for Sequence Modeling - Recurrent neural networks, attention based models. Speech applications - Automatic speech recognition. Course assignments and mini-project include programming and voice recordings.

Prasanta Kumar Ghosh

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.,DouglasO'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

Techniques for the analysis of action potentials, Local Field Potential (LFP) and Electroencephalogram (EEG). Techniques include stochastic processes, time-frequency analysis, sparse signal processing, coherence, ICA/PCA, forward and inverse modeling, Granger causality, and linear discriminant analysis.

Chandra Sekhar Seelamantula, Supratim Ray

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

EE 299 (JAN) 0:24

Project

MTech EE Project

Satish L

SP 299 (JAN) 0:28

Project

MTech SP Project

Navin Kashyap, Satish L

Dept of Electronic Systems Engineering

M Tech Electronic Systems Engineering

Duration: 2 Years			**Total Credits: 64**
Core Courses: 15 credits (All courses are compulsory)			
E0 284	2:1	Aug	Digital VLSI Circuits
E2 243	2:1	Aug	Mathematics for Electrical Engineers
E3 204	3:0	Jan	Fundamentals of MOS Analog Integrated Circuits
E3 235	2:1	Aug	Design for Analog Circuits
E3 257	2:1	Jan	Embedded System Design
Electives: 24 Credits (all at 200 level or higher) from the following courses or any other courses listed in the Scheme of Instructions.			
E1 201	2:1	Jan	Hardware Acceleration and Optimization for Machine Learning
E1 243	2:1	Jan	Digital Controller Design
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 200	1:2	Jan	Microelectronics Lab
E3 225	3:0	Jan	Art of Compact Modeling
E3 231	2:1	Jan	Digital System Design with FPGAs
E3 245	2:1	Aug	Processor System Design
E3 258	2:1	Jan	Design for Internet of Things
E3 260	2:1	Aug	Embedded System Design II
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	2:1	Jan	Physics and Design of Transistors
E3 276	2:1	Jan	Process Technology and System Engineering for Advanced Microsensors and Devices
E3 282	3:0	Jan	Basics of Semiconductor Devices and Technology
E3 301	3:0	Jan	Special Topics in Nanoelectronics
E6 202	2:1	Jan	Design of Power Converters
E6 212	3:0	Jan	Design and Control of Power Converters and Drives
E6 222	2:1	Jan	Design of Photovoltaic Systems
E9 251	3:0	Jan	Signal Processing for Data Recoding Channels
E9 252	3:0	Jan	Mathematical Methods and Techniques in Signal Processing
E9 253	3:1	Aug	Neural Networks and Learning Systems
Project: 25 Credits			
ED 299	0:25		Dissertation Project

Departments of Electronic Systems Engineering and Electrical Communication Engineering
MTech Microelectronics and VLSI Design

Duration: 2 Years			**Total Credits: 64**
Core Courses: 18 credits, mandatory for all students.			
E0 284	2:1	Aug	Digital VLSI Circuit
E3 200	1:2	Jan	Microelectronics Lab
E3 220	3:0	Aug	Foundations of Nanoelectronics Devices
E3 231	2:1	Jan	Digital Systems Design with FPGAs
E3 238	2:1	Aug	Analog VLSI Circuits
E3 282	3:0	Jan	Basics of Semiconductor Devices and Technology
Electives: 18 credits (all at 200 level or higher) from the following courses or any other courses listed in the Scheme of Instructions.			
E1 201	2:1	Jan	Hardware Acceleration and Optimization for Machine Learning
E3 225	3:0	Aug	Art of Compact Modelling
E3 237	3:0	Jan	Integrated Circuits for Wireless Communication
E3 245	2:1	Aug	Processor System Design
E3 257	2:1	Jan	Embedded System Design
E3 271	1:2	Jan	Reliability of Nanoscale Circuits and Systems
E3 274	1:2	Jan	Design of Power Semiconductor Devices
E3 275	2:1	Jan	Physics and Design of Transistors
E3 276	2:1	Jan	Process Tech & System Eng for Adv Microsensors and Devices
E3 280	3:0	Jan	Carrier Transport in Nanoelectronics Devices
E3 301	3:0	Jan	Special topics in Nanoelectronics
E7 211	2:1	Jan	Photonic Integrated Circuits
E7 214	3:0	Jan	Optoelectronic Devices
E8 202	2:1	Aug	Computational Electromagnetics
E8 242	2:1	Jan	RF IC and Systems
E8 262	3:0	Jan	CAD for High Speed Chip-Package-Systems
NE 203	3:0	Aug	Advanced Micro and Nano Fabrication Tech and Process
NE 205	3:0	Aug	Semiconductor Devices and Integrated Circuit Technology
NE 215	3:0	Aug	Applied Solid State Physics
NE 222	3:0	Aug	MEMS: Modeling, Design, and Implementation
NE 241	3:0	Aug	Material Synthesis: Quantum Dots to Bulk Crystals
NE 202	0:1	Jan	Device Fabrication Lab Module (Micro and Nano Fabrication)
NE 201	2:1	Jan	Micro and Nano Characterization Methods
NE 314	3:0	Jan	Semiconductor Opto-electronics and Photovoltaics
NE 221	2:1	Jan	Advanced MEMS Packaging Lab: Packaging Lab
IN 221	3:0	Aug	Sensors and Transducers

IN 229	3:0	Aug	Advanced Instrumentation Electronics
IN 212	3:0	Jan	Advanced Nano/Micro Systems
IN 214	3:0	Jan	Semiconductor Devices and Circuits
IN 224	3:0	Jan	Nanoscience and Device Fabrication
MT 209	3:0	Aug	Defects in Materials
MT 213	3:0	Jan	Electronic Properties of Materials
PH 203	3:0	Aug	Quantum Mechanics-I
PH 208	3:0	Jan	Condensed Matter Physics-I
PH 352	3:0	Jan	Semiconductor Physics
PH 359	3:0	Jan	Physics at Nanoscale
MR 303	3:0	Aug	Nanomaterials Synthesis and Devices
MR 307	3:0	Jan	Thin Film, Nano Materials and Devices: Science and Engg
MR 308	2:1	Jan	Computational Modeling of Materials
Project: 28 Credits			
MV 299	00:28		Dissertation Project

E0 284 (AUG) 2:1

Digital VLSI Circuits

Introduction to MOS transistor theory, circuit characterization and simulation, theory of logical effort and delay, combinational and sequential circuit design, standard cell layout, datapath subsystems, power and clock distribution, ASIC Chip Design methodology & tools including synthesis, design for test (DFT), place & route, verification.

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 232 (AUG) 2:1

TCP/IP Networking

IP addressing, IP header; subnetting and supernetting, CIDR, routing table, Ethernet, Frame Processing in Linux kernel, ARP; 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; Private IP; NAT; DHCP; http; Web application security; SDN; IPv6.

Prabhakar T V, Dagale Haresh Ramji, Joy Kuri

References :

- Kevin R. Fall, W. Richard Stevens,TCP/IP Illustrated,Vol I: The Protocols, Second Edition, Pearson; Internet RFC-s;

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 235 (AUG) 2:1

Design for Analog Circuits

Introduction to Op-Amps and Op-Amp Circuits, Single-Stage and Two-Stage Amplifiers, Amplifier types and Topologies, Instrumentation Amplifiers; Static and dynamic Errors in Op-Amp; Practical Application of transistors and Op-Amps, Error budgeting in various circuits; Current Mirrors, CCS and Active Loads, Temperature indicators and controllers, PID-controllers; Voltage regulators and power supplies, protection circuits; 4-20mA and other current transmitters; Designing Analog Circuits; Active Filters, LPF, HPF, BPF, BRF; Frequency Response and Feedback techniques; Nonlinear circuits, nonlinear and exponential transfer characteristics, Triggers, Comparators, rectifiers; Waveform generators, positive feedback, Oscillators, Converters; Instability and compensation; ADCs and DACs; Circuit simulation using Kicad and Ngspice; Understanding Datasheets.

Nagakrishna V

References :
- Sergio Franco, Design-With-Operational-Amplifiers-And-Analog-Integrated
- Peter D. Hiscocks, Analog Circuit Design
- Holger Vogt, Marcel Hendricks & Paolo Nenzi, Ngspice User's Manual - Version 32

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 Bus. 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.

Umanand L

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

E9 253 (AUG) 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 auto-encoders, stacked denoising auto-encoders

ShayanGarani Srinivasa

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

AI 299 (JAN) 0:21

MTech AI Dissertation Project

MTech AI Dissertation Project

Kuruvilla Varghese

E1 201 (JAN) 2:1

Hardware Acceleration and Optimization for Machine Learning

Overview of machine learning hardware systems, motivation and trends, fundamentals of digital hardware – FPGA, power and speed estimation, accelerating linear algebra, machine learning system concepts – (SVM and Deep Learning Neural Networks), feature extraction (PCA, filtering), inference engine, matrix vector multiplication (sparsity), non-linearity and pooling, resolution-performance trade-off, training optimization engines (cost function, regularization), online and stochastic training, forward-backward propagation, emerging hardware architectures, memristor based designs, spiking architectures.

Chetan Singh Thakur

References :
- Current literature

Pre-requisites :
- Basics of linear algebra, calculus, probability, basic knowledge of C/Python

E1 243 (JAN) 2:1

Digital Controller Design

Modelling of physical systems using bondgraph, state space representation, transfer function, z-domain analysis, continuous to discrete transformations, controller design using discrete root locus, controller design using full state feedback, output feedback, observer, reduced order observer, observer design, optimal controller and observer

Umanand L

References :
- Franklin, Workman and Powell, Digital control, Prentice Hall

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 200 (JAN) 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 204 (JAN) 3:0

Fundamentals of MOS Analog Integrated Circuits

Introduction to enhancement mode MOSFETs: MOS capacitor, CV characteristics, MOSFET – Device Physics of the MOSFET, Current voltage characteristics, Linear and saturation operation, MOSFET - Small Signal analysis techniques: transconductance, output impedance due to channel length modulation, small signal resistance, small signal circuit of MOSFETs, MOSFET as a Switch: Operation as a Switch, Switch-capacitor circuits- Dynamics, Time constants, Parasitics - clock feedthrough and charge injection, Charge sharing between capacitors Single Stage MOS Voltage Amplifiers: Voltage amplifiers: Single stage Topologies: Common source, common source with degeneration, common gate, common drain, cascode. CMOS technology and CMOS amplifiers, Small Signal, Low frequency analysis of MOS Single Stage voltage amplifiers, Small Signal, High frequency analysis of MOS Single Stage voltage amplifiers: Miller effect, transit frequency, dominant pole MOS Differential amplifiers: Concept and operation of Differential Amplifiers, Analysis of MOS differential amplifiers: Differential gain, Common mode gain, CMRR, Half circuit method Biasing Circuits: 2 MOSFET Current mirror, Impact of channel length modulation , Cascode current mirror, Self Biasing Circuits, Differential Amplifiers with Active Loads Frequency Response: Transfer function Poles, Zeros, Bode Plots, Stability of Systems, Frequency response of amplifiers, Miller Effect, Transit frequency of the MOSFET Noise: Noise in circuits: Characterization of Noise, Noise spectrum, Types of Noise: thermal noise, flicker noise, shot noise and their noise spectrum, Noise in RC circuits, Noise in MOSFETs: Corner frequency, analysis of noise in MOS voltage amplifiers, calculations of output and input referred noise in MOS circuits, Signal to noise ratio, Effective Noise Bandwidth Feedback: Concepts of Feedback, Analytical methods to calculate loop gain, closed loop gain, Feedback in circuits Operational Amplifiers: OPAMP architectures – Telescopic Cascode, Folded Cascode, Two Stage OPAMPs, Gain Boosted OPAMPS , Stability of OPAMPS -

Dominant Pole Compensation, Miller Compensation, Power Supply Rejection Ratio, Slew Rate. System Design: Problem solving and Analysis at the System level – eg. Image sensors, displays, biomedical applications. New technologies: Thin film transistors and Vacuum transistors. Device level challenges and impact on circuit design. Approach to circuit design and impact on system performance.

Sanjiv Sambandan

References :
- Design of CMOS Analog Integrated Circuits, B. Razavi, Mc Graw Hil
- Analysis and Design of Integrated Circuits, Gray, Hurst, Lewis, Meyer
- Research Papers

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

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,JosephYiu
- Practical Microcontroller Engineering with ARM Technology,YingBai,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.,andCrowley,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 CharvakaDuvvury, Wiley publication,Basic ESD and I/O Design by Sanjay Dabral and Timothy J. Maloney, Wiley publication

E3 272 (JAN) 3:0

Advanced ESD Devices, Circuits and Design Methods

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

Mayank Shrivastava

References :

• ESD Protection Device and Design for Advanced CMOS Technologies by Oleg Semenov, Hossein Sarbishaei and Manoj Sachdev, Elsevier

- ESD RF Technology and Circuits by Steven H. Voldman, Wiley
- Nanoelectronics – Nanowires, Molecular Electronics and Nanodevices by Krzysztof Iniewski, McGraw Hill

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, SorabKhushroGhandhi, Wiley, 1977,Advanced Power MOSFET Concepts, B. Jayant Baliga, 2010,High Voltage Devices and Circuits in Standard CMOS Technologies, Hussein Ballan, Michel Declercq

E3 275 (JAN) 2:1

Physics and Design of Transistors

1. The Ideal MOS Capacitor: The Silicon/Silicon Dioxide System, Band Bending in the MOS Capacitor, Solution of Poisson's Equation for the MOS Capacitor, Depletion Approximation, Threshold Voltage, Capacitance-Voltage (CV) Plot of the Ideal MOS Capacitor, Small-signal Capacitance and Equivalent Circuit, Low-frequency Capacitance-Voltage (LFCV) Characteristics, High-frequency Capacitance-Voltage (HFCV) Characteristics and Deep Depletion. 2. The Non-Ideal MOS Capacitor: Work Function Difference, Oxide and Interface Charges, Nature of Defects in the Oxide and at the Si/SiO2 Interface, Effect of Oxide Charges, Effect of Interface States, Stretchout in the HFCV Characteristic, Interface State Capacitance and Equivalent Circuit, LFCV Characteristic with Interface States, Effect of Border States, Series Resistance, Non-Uniform Doping, Lateral Non-Uniformities, Polysilicon Depletion Effects, Failure of Maxwell-Boltzmann Statistics, Quantum Effects and Tunnelling through the Insulator 3. The MOS Capacitor as a Diagnostic Device: Determination of Basic MOS Parameters - Oxide Thickness, Substrate Doping, The Ideal HFCV Curve, Flat-band and Mid-gap Capacitances and Voltages, Threshold Voltage and Work Function Difference. Oxide Charge and Interface States, Determination of Interface State Density, The HF-LF CV Technique, Conductance Method, Continuum of States, Deep Level Transient Spectroscopy (DLTS), Determination of Oxide Charge and Effects of Quantization on the Extraction of Parameters 4. The Long Channel MOSFET: Simplified I-V models of the MOSFET. Various MOSFET models and aspects like body effect, threshold voltage model, sub-threshold swing model, sub-threshold conduction, OFF and ON state behaviour using band diagrams, LF and HF CV characteristics. 5. The Short Channel MOSFET: Threshold voltage change with channel length scaling, Drain Induced Barrier Lowering, Channel Length Modulation, Velocity Saturation, Mobility Degradation, Punch-through, HC effects, parasitic bipolar effect, Gate Induced Drain Leakage, Effect of thin Gox, Transistor Scaling and scaling Implications. 6. Double Gate MOSFET and FinFETs: FDSOI and PDSOI. Limitation of FDSOI technology. Why FinFETs? FinFET advantages over FDSOI, FinFET Design, SOI vs. Bulk FinFETs, band diagram, scaling and variability issues/advantages, effect of Fin Width, effect of S/D resistance, mobility,

quantum confinement effects and bulk conduction. P and N conduction, impact of crystal plane. High-k & Metal Gate for FinFETs, Process flow and complexities, doping thin films, raised S/D, epitaxial S/D, stress and other mobility boosters. FinFET based circuit design advantages (Logic, SRAM, Analog/RF), limitations and other challenges. FinFET layout design rules. HV/ESD device and SoC design challenges in FinFETs. Basics of Nanowire FETs.

Mayank Shrivastava

Pre-requisites :

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

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

E3 282 (JAN) 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

E3 301 (JAN) 3:0

Special Topics in Nanoelectronics

Physics of Constrained Dimensions: 0D Nano-devices (Quantum Dots), 1D Nano-devices (Nanowires, Nanotubes and Nano-Ribbons), 2D Nano-devices (TMDs, Phosphorene & Graphene); Two Dimensional Electron Gas and Quantum Well Systems, Electro-thermal, thermal and electrical transport in 0D, 1D and 2D systems (CNT, Graphene, h-BN, Phosphorene and TMDs); Noise in nano-structures and nano-devices; Nanoelectronic Memories and Memristors; Memristor-based Neuromorphic Systems; Emerging Nanophotonic Applications using 0D, 1D and 2D material systems; Applications of 2D material heterostructures in Photodetectors, memories, tunnel FETs and THz detectors; applications of Graphene-h-BN heterostructure and other applications of graphene.

Mayank Shrivastava

References :
- Review Articles
- Research Papers

Pre-requisites :
- E3-282: Basics of Semiconductor Devices and Technology
- E3-275: Physics and Design of Transistors

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 252 (JAN) 3:0

Mathematical methods and techniques in signal processing

Review of basic signals, systems and signal space: Review of 1-D signals and systems, review of random signals, multi-dimensional signals, review of vector spaces, inner product spaces, orthogonal projections and related concepts. Basics of multi-rate signal processing: sampling, decimation and interpolation, sampling rate conversion (integer and rational sampling rates), oversampled processing (A/D and D/A conversion), and introduction to filter banks. Signal representation: Transform theory and methods (FFT and variations, KLT), other transform methods. Statistical signal modeling: The least squares method, Pade's approximation, Prony's method, Shanks' method, iterative pre-filtering, all-pole modeling and linear prediction, autocorrelation and covariance methods, FIR least squares inverse filter design, applications and examples. Inverse problems (signal reconstruction): underdetermined least squares, pseudo-inverse (SVD), min-norm solutions, regularized methods, reconstruction from projections, iterative methods such as projection onto convex sets, expectationmaximization and simulated annealing.

ShayanGarani Srinivasa

Pre-requisites :

- Moon & Stirling, Mathematical Methods and Algorithms for Signal Processing, Prentice Hall, 2000 (required),Monson Hayes, Statistical Digital Signal Processing and Modeling, John Wiley and Sons, 1996 (optional),Class Notes

ED 299 (JAN) 0:25

MTech ESE Dissertation Project

MTech ESE Dissertation Project

Kuruvilla Varghese

MV 299 (JAN) 0:28

MTech Micro & VLSI Dissertation Project

MTech Microelectronics and VLSI Design Dissertation Project

Kuruvilla Varghese

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. 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
Dean
Division of Mechanical Sciences

Dept of Aerospace Engineering

MTech Curriculum

Core courses → 15 credits

Experimental techniques in aerospace engineering → 1 credit

Aerospace seminar → 1 credit

Math requirement → 3 credits

MTech project dissertation → 20 credits

Electives → 24 credits

Total → 64 credits (minimum)

MTech Dissertation adviser to be chosen by the MTech student at the end of first semester.

Math requirement, all electives, and the independent study course, will be credited by a student in consultation with the MTech dissertation adviser. Students should register for a minimum of 12 credits per semester :

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

Core courses

AE 201 (AUG) 3:0

Flight and Space Mechanics

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

Ramesh O N

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.

Sourabh Suhas Diwan

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.
- F M White, Fluid Mechanics, McGraw Hill Education, 2015.
- R L Panton, Incompressible Flow, John Wiley and Sons, 2013.
- J. D. Anderson, Fundamentals of Aerodynamics, McGraw Hill Education, 2010.

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
- NicholasCumpsty 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.

Dinesh Kumar Harursampath

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.

Ashwini Ratnoo, Debasish Ghose, 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 227 (AUG) 3:0

Numerical Fluid Flow

Introduction to CFD, equations governing fluid flow, hyperbolic partial differential equations and shocks, finite difference technique and difference equations, implicit difference formula, time discretization and stability, schemes for linear convective equation, analysis of time integration schemes, monotonicity, schemes for Euler equations, finite volume methodology. Introduction to unstructured mesh computations.

Balakrishnan N(CFD)

References :

- Charles Hirsch, Numerical Computation of Internal and External Flows, Vols.1-2, Wiley-Interscience publication, 1990.

Pre-requisites :

- AE 202 or equivalent.

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 255 (AUG) 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 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.

SiddanagoudaKandagal

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.

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.

Arnab Samanta, Joseph Mathew

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.

Gopalan Jagadeesh, Joseph Mathew, 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 227 (JAN) 3:0

Numerical Fluid Flow

Introduction to CFD, equations governing fluid flow, hyperbolic partial differential equations and shocks, finite difference technique and difference equations, implicit difference formula, time discretization and stability, schemes for linear convective equation, analysis of time integration schemes, monotonicity, schemes for Euler equations, finite volume methodology. Introduction to unstructured mesh computations.

Balakrishnan N(CFD)

References :
- Charles Hirsch, Numerical Computation of Internal and External Flows, Vols.1-2, Wiley-Interscience publication, 1990.

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 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.

Dinesh Kumar Harursampath, Narayana Naik G

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 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.

SiddanagoudaKandagal

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 264 (JAN) 3:0

Vibrations

Concepts from linear system theory; Principles of analytical dynamics; Single-degree-of-freedom systems; Multi-degree-freedom systems, The algebraic eigenvalue problem; Distributed parameter systems and approximate methods for their solution; Parametric and nonlinear vibration.

Kartik Venkatraman

References :

- Meirovitch, L. (1997). Principles and Techniques of Vibrations. Upper Saddle River, New Jersey, USA: Prentice-Hall International Inc. Newland, D. E. (2006). Mechanical vibration analysis and computation. Mineola, New York, USA: Dover Publications.

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

Ashwini Ratnoo, Debasish Ghose

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 297 (JAN) 0:1

Aerospace Seminar

Aerospace Seminar is a 1 credit course offered 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

Kartik Venkatraman

References :

- AE Seminar

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 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.

RadhakantPadhi

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

M Tech Programme in Climate Science (2020 and LATER BATCH STUDENTS)

Duration: 2 years

64 credits

Soft Core courses: 21 credits (7 COURSES out of 9)

AS 202	3:0	Geophysical Fluid Dynamics
AS 203	3:0	Atmospheric Thermodynamics
AS 204	3:0	Atmospheric Radiation and Climate
AS 205	2:1	Ocean Dynamics
AS 207	3:0	Introduction to Atmospheric Dynamics
AS 210	3:0	Numerical methods in atmospheric modeling
AS 211	2:1	Observational Techniques
AS 215	3:0	Environmental Fluid Dynamics
AS 216	3:0	Introduction to Climate System

Mathematics Requirement: 3 credits (compulsory)

AS 209 3:0 Mathematical Methods in Climate Science

or

An equivalent Mathematics course offered by the Department of Mathematics , SERC, CDS, CEaS, or Department of Chemical Engineering

Project: 28 Credits

AS 299 0:28 Dissertation Project

Electives: 12 credits

The balance of **12** credits required to make up a minimum of **64 credits** to complete the M.Tech Program.

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 215 (AUG) 3:0

Environmental Fluid Dynamics

An overview of the field of fluid mechanics and description of the physics governing fluid flow. Principles of buoyancy-driven flow: Free-surface flows, gravity currents, stratified flows, gravity waves. Heat transfer and fluid instability: Convection, turbulence, and mixing. The course has four major components: (i) Waves in fluids: interfacial waves and internal gravity waves. (ii) Vertical flows: turbulent plumes, filling box, double-diffusive convection. (iii) Horizontal flows: shallow water approximation, single-layer hydraulics, gravity currents, two-layer flows, and (iv) Turbulent mixing: mixing across very stable interfaces and turbulent convection. The course consists of Lectures, tutorials, and simple laboratory experiments.

BishakhdattaGayen

References :
• Fluid Mechanics 3rd Edition: Authors: Ira Cohen and Pijush Kundu: Academic Press, Published Date: 2004
• Buoyancy Driven Flow: Authors: J. S. Turner: Cambridge University Press, Published Date: 1979
• Waves in the Ocean and Atmosphere: Introduction to Wave Dynamics: Authours: J. Pedlosky, Spriger Verlag, Published Date: 2003

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.

Jai SuhasSukhatme, Debasis Sengupta

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 VonderHaar, 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.BNumericalOceanCirculation Modeling, Imperial College Press, 1999.
- Chassignet and Vernon J.(ED), Ocean Modeling and Parameterization.
- NATO Advanced Study Institute, Kluwer Academics, 1988.

Dept of Civil Engineering

Scheme of Instruction for M Tech Civil Engineeringprogram (2020-21)

Semester 1 Common to all students
Core: 18 Credits
CE 201 3:0 Basic Geomechanics
CE 2753:0 Transportation Systems Modelling
CE 2173:0 Fluid Mechanics
CE 204 3:0 Solid Mechanics
CE 205 3:0 Finite Element Method(For the year 2020-21, this course is shifted to the February semester.It remains a core course for all MTech students, irrespective of their major)

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 three Areas**, a student must complete minimum of 12 credits in the said Area.

Major in Geotechnical Engineering

Core:12 Credits (+ 3 credits from term 1)
CE 202 3:0 Foundation Engineering
CE 2063:0Earth and Earth RetainingStructures
CE 2073:0GeoenvironmentalEngineering
CE 208 3:0Ground Improvement and Geosynthetics
CE299 0:22 Dissertation Project

Major in Structural Engineering

Core: 9 Credits (+ 6 credits from term 1)
CE 209 3:0 Mechanics of Structural Concrete
CE 210 3:0Structural Dynamics
CE 2283:0 Continuum Plasticity
CE299 0:22 Dissertation Project

Major in Water Resources Engineering

Core: 12 Credits (+ 3 credits from term 1)
CE 203 3:0 Surface Water Hydrology
CE 2133:0 Systems Techniques in Water ResourcesEngineering
CE 214 3:0 Ground Water Hydrology
CE 215 3:0 Stochastic Hydrology
CE2990:22Dissertation Project

Major in Transportation Systems Engineering

Core: 12 Credits(+ 3 credits from term 1)

CE 269 3:0 Traffic Engineering
CE 262 3:0 Public Transportation Systems Planning
CE 272 3:0 Traffic Network Equilibrium
CE 235 3:0 Optimization Methods
CE 299 0:22 Dissertation Project

Electives inGeotechnical Engineering

CE220 3:0 Design of Substructures
CE 221 3:0 Earthquake Geotechnical Engineering
CE 222 3:0Fundamentals of SoilBehaviour
CE 227 3:0 Engineering Seismology
CE 231 3:0 Forensic Geotechnical Engineering
CE 279 3:0 Computational Geotechnics

Electives in Structural Engineering
CE 216 3:0 Random Vibration and Reliability Analyses
CE 229 3:0 Non-Destructive Evaluation Methods for Concrete Structures
CE 234 3:0 Nonlinear analysis in earthquake engineering
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 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
CE 277 3:0 Remote Sensing in Ecohydrology
AS 216 3:0 Introduction to Climate Systems

Electives in Transportation Systems Engineering

CE 271 3:0 Choice Modelling
CE 273 3:0 Markov Decision Processes
DS 290 3:0 Modelling and Simulation
ST 203 3:0 Technology and Sustainable Development
MG 221 3:0 Applied Statistics

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

TejasGorur Murthy

References :

- Wood,D.M.,SoilBehaviour and Critical State Soil Mechanics,Cambridge University Press,1991.

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 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.

Tarun Rambha, Debraj Ghosh

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 217 (AUG) 3:0

Fluid Mechanics

Vectors and tensors, divergence theorem, pressure, Archimedes principle, fluid mass conservation, heat and contaminant conservation, momentum conservation and Cauchy equation, stress tensor, constitutive relation for Newtonian fluids, Navier-Stokes equations, vorticity, laminar plane couette and open channel flow, Euler equations, potential flow approximation, simple solutions of potential flows, laminar flow in pipes and channels, transition to turbulence Reynolds stress and fluxes, laminar boundary layer, laminar bottom dense flows.

Dutta Debsunder

References :

- Kundu, Cohen and Dowling Fluid Mechanics, Sixth Ed., Academic Press, 2016.
- White, F.M. Fluid Mechanics, Eighth Edition, McGraw Hill, 2016.

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 234 (AUG) 3:0

Nonlinear Analysis in Earthquake Engineering

Earthquake load specification via time histories and response spectra. Seismic hazard. Spectrum compatible accelerograms. Numerical integration of equations of motion. Geometric and material nonlinear behaviour. Characterization of hysteresis, strength and stiffness degradations, pinching, and residual deformations. Oscillator models for inelastic behaviour. Internal variables. Energy dissipation characteristics. Models for seismic demands and capacities. Inelastic response spectrum. Ductility demand and yield capacity. P- ? effects. Global damage indices. Oscillator and FE based models for buildings and bridges under earthquake loads. Vibration isolation. Soil-structure interactions. Seismic collapse capacity using nonlinear static and incremental dynamic analyses. Capacity spectrum. Seismic fragility and vulnerability analyses. Performance based earthquake engineering formats.

Manohar C S

Pre-requisites :

- Chopra, A K, 1996, Dynamics of structures, Prentice Hall, New Dehli.
- Villaverde, R, 2009, Fundamental concepts of earthquake engineering, CRC Press, Boca Raton.

- Elnashai A S, and L D Sarno, 2008, Fundamentals of earthquake engineering, Wiley, Chichester.
- Current Literature

CE 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 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 248 (AUG) 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 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 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 275 (AUG) 3:0

Transportation Systems Modelling

Methods – Statistical and econometric methods for transportation data analysis; linear regression for analysis of continuous variable data (assumptions, estimation, specification, interpretation, hypothesis testing, segmentation, non-linear specification, testing of assumptions); discrete outcome models for analysis of categorical data (binary and multinomial choice models, maximum likelihood estimation); entropy methods for analysis of spatial flows; Demand-supply equilibrium; Models of traffic flow; Optimization models to predict traffic volumes. Applications – analysis of user behaviour in infrastructure systems; travel behaviour, travel demand and supply analysis (modelling the generation, spatial and temporal distribution, modal split, and route choice of travel); analysis of vehicular traffic streams; tools for data analysis and transport modelling.

Abdul RawoofPinjari

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, 2006.

CE 202 (JAN) 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.

TejasGorur Murthy

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 (JAN) 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.

Mujumdar P P

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 205 (JAN) 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 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 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.

Srinivas V V

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.

Nagesh Kumar D

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 222 (JAN) 3:0

Fundamentals of Soil Behaviour

Identification and classification of clay minerals, expansive and collapsing soils; Concepts and measurements of matric and osmotic suction, Role of inter-particle forces and suction in effective stress, Role of clay mineralogy, inter-particle forces and suction in volume change, hydraulic conductivity and shear strength of soils

Sudhakar Rao M, Raghuveer Rao P

Pre-requisites :
• Mitchell, J. K. Fundamentals of Soil Behaviour, Wiley, 2005.,Yong, R. N. and Warkentin, B. P. Soil Properties and Behaviour, Elsevier, 1975, Lu, N. and Likos, W.J. Unsaturated Soil Mechanics, Wiley, 2004,Fredlund, D.G. and Rahardjo, H., Fredlund, M.D. Unsaturated Soil Mechanics in Engineering Practice, Wiley, 2012,Nelson, J.D. and Miller, D.J. Expansive soils- Problems and Practice in Foundation and Pavement Engineering. Wiley- Interscience Pub., 1992

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 231 (JAN) 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 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 269 (JAN) 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 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 RawoofPinjari

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 277 (JAN) 3:0

Remote Sensing in Ecohydrology

Introduction to ecohydrology, fundamentals of exchange of energy and water in terrestrial ecosystems, soil temperature and moisture, surface energy fluxes, modeling leaf photosynthesis and stomatal conductance, introduction to plant canopies and radiation regime, soil, plant atmosphere continuum, fundamentals of optical remote sensing, remote sensing of vegetation composition, structure and function, applications of remote sensing to coupled water and carbon cycles in terrestrial ecosystems.

Dutta Debsunder

References :

- Ecological Climatology, 3rd Edition, Gordon Bonan, Cambridge University Press.
- An Introduction to Environmental Biophysics, 1998, G.S. Campbell, J. Norman, Springer.

CE 279 (JAN) 3:0

Computational Geotechnics

Introduce governing equations for geotechnical engineering problems, basics of solving governing equations using frequency and time domain numerical methods including finite element and finite difference methods, soil constitutive modeling, examples of coding/solving geotechnical engineering problems using the above methods/tools.

References :

- Bathe, K.J., Finite Element Procedures in Engineering Analysis, Prentice-Hall, Englewood Cliffs, NJ, 1982.
- Wood, D.M., Soil Behavior and Critical State Soil Mechanics, Cambridge University Press, New York, 1990.
- Hai-Sui Yu, Plasticity and Geotechnics, Springer, 2006
- Desai, C.S. and Christian, J.T. Eds. Numerical Methods in Geotechnical Engineering, McGraw-Hill, 1977.

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

Dept of Chemical Engineering

Coursesin the Department : August 2020

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 contentof the active courses in a given academic year is appended below. Please note that all the courses listed above are *not*active every year.

The table below shows the department requirements for its various programmes.

Programme	Credits	DepartmentRequirements
M Tech Programme, duration 2 years	64	Course work of 32 creditsincludes a core of 17 credits (CH 201 to CH 207), and a soft core of 6 credits from the department offerings.The project work is equivalent of 32 credits.
M Tech (Res) Programme	12	CH 201 or CH 202, anda minimum of two from CH 203, CH 204, and CH 205. CH 206 and CH 207 are compulsory. A maximum of 21 credits is permitted.
PhD Programme, after Bachelor's degree	24	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. Solution of inhomogeneous differential equations, Green's function. Elementary perturbation theory.

Ananth Govind Rajan, Prabhu R Nott

References :

- Linear Algebra and its Applications,GilbertStrang,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).
- An Introduction To Partial Differential Equations, Y. Pinchover and J. Rubinstein, Cambridge University Press (2005).

Pre-requisites :
- A basic course in Engineering or Applied Mathematics, including linear algebra, ordinary and partial differential equations.
- UG students must seek approval of one of the instructors 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
- Beers, K.J., Numerical Methods for Chemical Engineering, Cambridge Univ. Press, Cambridge, UK 2010

Pre-requisites :
- Graduate students (not open to UGs)

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 299 (AUG) 0:32

Dissertation Project

The ME project is aimed at training the students to analyze independently any problem posed to them. The project may theoretical, experimental, or a combination. In few cases, the project may also involve sophisticated design work. The project report is expected to show clarity of thought and expression, critical appreciation of the existing literature, and analytical, experimental or design skills.

Venugopal S

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, D., Glasser, B., and Metzger, M., Attainable Region Theory– An Introduction to Choosing an Optimal Reactor • Levenspiel, O., Chemical Reactor Omnibook • Stewart, W. E., and Caracotsisos, M., Computer-Aided Modeling of Reactive Systems • Mory, M., Fluid Mechanics for Chemical Engineering •Pangarkar, V. G., Design of Multiphase Reactors • Ranade, V., Computational Flow Modeling for Chemical Reactor Engineering

Pre-requisites :
• Undergrad level CRE course

CH 207 (JAN) 1:0

Applied statistics and design of experiments

Overview of Applied Statistics; Introduction to Conditional Probability; Bayesian Inference for Parameter Estimation.

Venugopal S

References :
• Stewart, W. E., and Caracotsisos, M., Computer-Aided Modeling of Reactive Systems

Pre-requisites :
• Undergraduate level CRE course

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 236 (JAN) 3:0

Statistical Thermodynamics

Introduction to ensembles, partition functions, relation to thermodynamics; imperfect gases; density distribution functions; integral equations and perturbation theories of liquids; lattice gas; Ising magnets; Bragg Williams approximation; Flory Huggins theory; Molecular modeling of intermolecular forces

Ganapathy Ayappa, Sudeep Punnathanam

References :

- McQuarrie, D.A., Statistical Mechanics, Viva Books, 2003.
- Hill, T. L., An Introduction to Statistical Thermodynamics, Dover Publications, 1986.
- Chandler, D, Introduction to Modern Statistical Mechanics, Oxford University Press, New York, 1986

CH 244 (JAN) 3:0

Treatment of drinking water

Availability of water; contaminants and their effects on human health; quality standards; removal of contaminants by various processes: chlorination, filtration, coagulation and flocculation, reverse osmosis, adsorption and ion exchange; rainwater harvesting; Sodis

Kesava Rao K

References :

- Droste, R. L., Theory and Practice of Water and Wastewater Treament, Wiley (Asia) 2004,World Health Organization, Guidelines for Drinking-water Quality, 4th ed. incorporating the 1st addendum,2011, World Health Organization 2017,Current Literature

Pre-requisites :

- Droste, R. L., Theory and Practice of Water and Wastewater Treament, Wiley (Asia) 2004,World Health Organization, Guidelines for Drinking-water Quality, 4th ed., 2011,Current Literature

CH 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 are

Venugopal S

Dept of Mechanical Engineering

MTechProgram
Duration:2years
Total: 64credits

Soft Core courses (4 out of 5)

ME201	3:0	FluidMechanics
ME228	3:0	MaterialsandStructureProperty Correlations
ME240	3:0	Dynamics& Controlof MechanicalSystems
ME242	3:0	SolidMechanics
ME271	3:0	Thermodynamics

(Soft Core) Math requirement

ME 261 3:0 Engineering Mathematics
OR
AE211 3:0 Mathematical Methods for Aerospace engineers

Seminar Course requirement

ME297 1:0SeminarCourse

Project : 27Credits
ME2990:27Dissertation Project

Electives:7 Courses (21credits).

MTech (Res)
Duration: (min) 1 - 3 (max) years
Electives: (min) 12 - 21 (max) credits

(Soft Core) Math requirement
ME 261 3:0 Engineering Mathematics
OR
AE 211 3:0 Mathematical Methods for Aerospace engineers

Direct Ph.D. program
Duration:(min) 3 – 6 (max) years
Electives:(min) 24 – 33 (max) credits

(Soft Core) Math requirement
ME 261 3:0 Engineering Mathematics
OR

AE 211 3:0 Mathematical Methods for Aerospace engineers

Following successful completion of the RTP, the student will be eligible to appear for the comprehensive examination /general test provided they have secured CGPA (7/10) which is computed based on the *basket rule* based on the best grades for all courses that make-up the minimum RTP credit requirement. The comprehensive exam must be taken within 2 years from the date of registration. 1 semester of Teaching Assistantship (TA) is compulsory. No other specific requirements from the department aside from adherence to Institute policies.

Ph.D. Program

Duration: (min) 2 – 6 (max) years

Following successful completion of the RTP, the student will be eligible to appear for the comprehensive examination /general test provided they have secured CGPA (7/10) which is computed based on the *basket rule* based on the best grades for all courses that make-up the minimum RTP credit requirement. The comprehensive exam must be taken within 2 years from the date of registration. 1 semester of Teaching Assistantship (TA) is compulsory. No other specific requirements from the department aside from adherence to Institute policies.

A research student may credit courses in addition to the ones required for RTP. These are the non-RTP courses and maybe taken before or after the Comprehensive/General Test. There is no restriction on the number of such courses. Only courses with grades C or better will be listed in the transcript; these grades are not used for calculating the CGPA.RTP and non-RTP courses have to be chosen after careful consultation with the Research Supervisor/DCC. RTP and non-RTP courses cannot be interchanged after the registration.

ME 201 (AUG) 3:0

Fluid Mechanics

Fluid as a continuum, mechanics of viscosity, momentum and energy theorems and their applications, compressible flows, kinematics, vorticity, Kelvin's and Helmholtz's theorems, Euler's equation and integration, potential flows, Kutta-Joukowsky theorem, Navier-Stokes equations, boundary layer concept, introduction to turbulence, pipe flows.

Ratnesh K Shukla, Aloke Kumar

Pre-requisites :

- Kundu,P.K.,andCohen,I.M.,Fluid Mechanics

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.

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,SecondEdn.,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 :

- c. s. jog

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.

Bobji M S

Pre-requisites :

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

ME 260 (AUG) 3:0

Structural Optimiztion:Size, Shape, and Topology

A quick overview of finite-variable optimization and calculus of variations. Analytical size optimization of bars and beams for stiffness, flexibility, strength, and stability criteria in the framework of variational calculus. Gradient-based computational optimization of trusses, frames, and continuum structures. Sensitivity analysis for parameter, shape, and topology variables. Shape optimization. Topology optimization. Design parameterization for topology optimization of coupled structural problems involving thermal, electro-thermal, electrostatic, fluid, and other multiphysics domains.

Ananthasuresh G K

References :

- NPTEL MOOC: https://nptel.ac.in/courses/112/108/112108201/
- 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.
- Haug, E. J., Choi, K. K., and Komkov, V., “Design Sensitivity Analysis of Structural Systems,” Academic Press, 1986.

Pre-requisites :

- Multivariable calculus and programming experience in MATLAB are preferred. Familiarity with finite element analysis is recommended.

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.

Gaurav Tomar, Koushik Viswanathan, Venkata R Sonti

Pre-requisites :

- KryyzigE,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, Pradip Dutta, 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 280 (AUG) 3:0

Fundamentals of nanoscale conduction heat transport

General introduction to the basic rules of quantum mechanics; crystal lattice definitions; reciprocal lattice; harmonic and anharmonic potential energy of the crystal; phonons as normal modes/eigenmodes of the crystal lattice vibrations; harmonic properties of the phonons - wavelength, wavevector, dispersions, group velocities and heat capacity; Einstein and Debye models; anharmonic phonon-phonon interactions; Fermi's golden rule and applications to phonons; anharmonic properties of phonons - phonon scattering rates, phonon lifetimes and phonon mean free paths; properties of the phonon-phonon collision matrix; momentum-conserving and momentum-dissipating scattering processes; Boltzmann equation for phonon transport; thermal conductivity; diffusive and non-diffusive heat transport.

Navaneetha Krishnan Ravichandran

References :
- Electrons and Phonons: The Theory of Transport Phenomena in Solids, by J. M. Ziman, Oxford University Press.
- Nanoscale Energy Transport and Conversion: A Parallel Treatment of Electrons, Molecules, Phonons, and Photons, by Gang Chen, Oxford University Press.

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.,andAcosta,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.,andKreider,J.F.,Principles of Solar Thermal Engineering

ME 290 (AUG) 3:0

Mechanics of slender elastic structures

A graduate level course emphasizing geometrically nonlinear problems in structural mechanics. This class can be considered a logical sequence to previous courses on solid/continuum mechanics. Topics covered (in roughly chronological order) Linear elasticity solution for beams - Airy stress functions - Dependence of displacements/stresses/energies on slenderness ratio Linear beam theories (Euler-Bernoulli beams) - Kinematic assumptions - Constitutive assumptions - Equilibrium - Comparison with linear elasticity solutions Local differential geometry for planar curves - Regular parameterizations - Arc length as a limit of chord lengths - Tangents, normals and signed curvature - Fundamental theorem for plane curves Nonlinear beam theories (Special Cosserat model) - Geometric description with base curves and directors - Kinematic assumptions, rotations of sections - Strain measures and interpretations - Equilibrium conditions - Linear constitutive relationship Special problem: Elastica - Kinematic assumptions and corresponding parameterization of solutions - Equilibrium, exact solution and elliptic integrals - Analogy with pendulum - Qualitative solution features from phase portraits - Interpretation of phase portraits and solutions shapes Stability - Three common notions of stability, min energy criterion - Directional derivatives - Energy functional, first and second variations - Equilibrium configurations, principle of virtual work - Sufficient condition for stability from second variations - Bifurcation points, stable and unstable branches - Examples with 1 and 2-dof systems - Linearized stability analysis, comparisons and examples - Stability of the elastica - Existence of energy functionals (Vainberg's theorem) Solution of nonlinear algebraic equations - Newton's algorithm - Analysis of Newton's method: sufficient conditions for convergence and convergence rate - Interpretation of Newton's method as a fixed point iteration - Arc-length methods - Implementation aspects

Ramsharan Rangarajan

References :

- Shames &Dym, Energy and finite element methods in structural mechanics.
- Hjelmstad, Fundamentals of structural mechanics
- Piero Villaggio, Mathematical models for elastic structures.
- Timoshenko, Theory of elastic stability

Pre-requisites :

- Prefereably: Solid mechanics, finite element methods

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.

Koushik Viswanathan

Pre-requisites :

- Faculty Coordinator

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 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 254 (JAN) 3:0

Compliant Mechanisms

Systematics and mobility analysis of compliant mechanism. Discrete and distribute compliance. Methods of elastostatic and elastodynamic analysis including multi-axial stiffness, pseudo-rigid-body, and spring-mass-lever models. Non-dimensional analysis of compliant topologies. Energetics including mechanical advantage and efficiency; static and dynamic balancing; and bistability and multistabillity. Synthesis and design methods including rigid-body replacement, topology optimization, building blocks, constraint theory, and selection maps. Applications in automotive, aerospace, biomedical, consumer products, and microelectromechanical systems.

Ananthasuresh G K

References :

• NPTEL MOOC: https://nptel.ac.in/courses/112/108/112108211/
• Instructor’s notes.
• L. L. Howell, Compliant Mechanisms, Wiley, 2001.

Pre-requisites :

• Multivariable calculus and programming experience in MATLAB are preferred. Familiarity with kinematics and mechanisms is recommended.

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.

Ramsharan Rangarajan

References :

• Cook, R.D., Malkus, D.S., and Plesha, M.E., Concepts and Applications of Finite Element Analysis,,ThirdEdn, 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.

SaptarshiBasu, 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 284 (JAN) 3:0

Applied Combustion

Thermodynamics and Thermochemistry, Chemical equilibrium, adiabatic flame temperature, Chemical kinetics, Constant pressure and constant volume fixed-mass reactors, well-stirred reactor, Plug-flow reactor, Conservation Equations, Laminar Premixed and Diffusion Flames, Droplet Combustion, Introduction to Turbulent Combustion, Combustion in Gasoline and Diesel Engines, Combustion Chamber Design, Pollutant Formation, Exhaust after-treatment, Advanced Engine Concepts, Gas Turbine Combustors – design requirements, stability and emissions.

Ravikrishna, R. V.

Pre-requisites :

- An Introduction to Combustion, Stephen R. Turns, McGraw Hill, 2011. Combustion Engineering,,Kenneth W. Ragland and Kenneth M. Bryden, Taylor & Francis, 2011. Heywood, J.B., Internal,Combustion Engine Fundamentals, McGraw Hill Intl Edn, 1988.

ME 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 Environment al Engineering, Prentice Hall, Inc., Englewood Cliffs, New Jersey, 1970.,ASHRAE Handbooks (SI Editions): Fundamentals (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 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.

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 299 (JAN) 0:27

Dissertation Project

The M. E. Project is aimed at training students to analyse independently any problem posed to them. The project may be a purely analytical piece of work, a completely experimental one, or a combination of both. In a few cases, the project may also involve sophisticated design work. The project report is expected to show clarity of thought and expression critical appreciation of the existing literature and analytical and/or experimental or design skill.

ME 303 (JAN) 3:0

Partial Differential Equations with Applications

Classification of partial differential equations: Linear, Semilinear, Quasi-linear and Nonlinear partial differential equations. Hyperbolic, Elliptic and Parabolic Equations. Method of solutions: integral curves and surfaces of PDEs, method of characteristics, separation of variables, Green's functions for elliptic problems and integral transforms. Complex potential theory. Introduction to Holder spaces, Banach spaces and Sobolov spaces. Basics of asymptotic analysis.

Gaurav Tomar, Venkata R Sonti

References :

• Introduction to Partial Differential Equations with Applications by Zachmanoglou and Thoe; An Introduction to Partial Differential Equations by Renardy and Rogers; Applied Partial Differential Equations by R. Haberman; Elements of Partial Differential Equations by Ian N. Sneddon; Introduction to Partial Differential Equations by L. C. Evans

Dept of Materials Engineering

M. Tech in MATERIALS ENGINEERING
(Duration: 2 Years, 64 credits)

MTech students: 32 credit course work (Sem I and Sem II) + 32 credit dissertation (Sem III and Sem IV)
Minimum mandatory credits from courses within the department: 8 (3+3+2) credit hard core + 9 (3 +3+3) credits from among the basket of soft core + 9 credits from among the softcore/electives. The remaining 6 credits can be completed without restrictions (within or outside the department).

PhD students with M Tech background need to take a minimum of 12 credits and pass with minimum CGPA of 7.00. PhD students with BE/BTech/MSc degree must take a minimum of 24 credits and pass with a minimum CGPA of 7.0.

Students with BE/BTech/MSc degree joining the M Tech (Research) program or joining the PhD program and opting for additional M Tech (Research) degree are required to take minimum of 50 % of their total required credits from the basket of hard cores and soft cores offered by the department. This implies that students in M. Tech (Research) should take minimum 6 credits and students desirous of M. Tech (Research) degree together with PhD degree should take 12 credits from the basket of hard cores and soft cores.

(3 extra credits in MT 250 is mandatory for those who don't have a prior background in materials related discipline. This is a non-RTP course for PhD and M. Tech (Research) students which the student must pass with minimum C-grade.)

Hard core (8 credits)

MT 202	3:0	Thermodynamics and Kinetics
MT 241	3:0	Structure and Characterization of Materials
MT 243	0:2	Laboratory Experiments in Materials Engineering

Soft core (9 credits): At least three out of the following courses

MT 209	3:0	Defects in Materials
MT 213	3:0	Electronic Properties of Materials
MT 220	3:0	Microstructural Engineering of Structural Materials
MT 231	3:0	Interfacial Phenomenon in Materials Processing
MT 253	3:0	Mechanical Behaviour of Materials
MT 260	3:0	Polymer Science and Engineering
MT 271	3:0	Introduction to Biomaterials and Engineering

Project (32 credits)

MT 299 0:32 Dissertation Project

Electives (15 credits): At least 9 credits must be taken from the courses offered by the Department.

MT 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.

Sai Gautam Gopalakrishnan

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 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, CelulaAutomata,: 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 225 (AUG) 3:0

Deformation and Failure Mechanisms at Elevated Temperatures

Phenomenology of Creep, Microstructural considerations in metals, alloys, ceramics and composites. Creep mechanisms, Deformation mechanism maps, Superpasticity in metal alloys, ceramics and nanophase materials, Commercial applications and considerations, Cavitation failure at elevated temperatures by nucleation, growth and interlinkage of cavities.

Atul H Chokshi

References :
- J. P. Polreer, Creep of Crystals, Cambridge University Press, Cambridge, 1984

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.

Praveen Kumar

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

MT 260 (AUG) 3:0

Polymer Science and Engineering

Fundamentals of polymer science: Polymer nomenclature and classification. Current theories for describing molecular weight, molecular weight distributions. Synthesis of monomers and polymers. Mechanisms of polymerization reactions. Introduction to polymer compounding and processing (for thermoplastic/thermosets). Structure, property relationships of polymers: crystalline and amorphous states, the degree of crystallinity, cross-linking, and branching. Stereochemistry of polymers. Instrumental methods for the elucidation of polymer structure and properties such as thermal (DSC, TGA, DMA, TMA, TOA), electrical (conductivity, dielectric), and spectroscopic (IR, Raman, NMR, ESCA, SIMS) analysis GPC, GC-MS.

Suryasarathi Bose

References :

- Principles of Polymerization, George G Odian, John Wiley and Sons
- Textbook of Polymer Science, F. W. Bilmeyer, John Wiley and Sons
- F. W. Bilmeyer, John Wiley and Sons The Elements of Polymer Science and Engineering,
- A. Rudin and P Choi, Academic Press Plastic Materials, J. A. Brydson, Elsevier

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

Elements of microstructure; Role of microstructure on properties; Review of crystalline defects; Methods of controlling microstructures: materials processing routes, heat treatments, phase transformations and mechanisms; Processing of cast and wrought alloys, Processing of nanostructured materials, processing of single crystals, Introduction to light metal alloys (Al-based, Mg-based and Ti-based), Introduction to high temperature superalloys, Introduction to high entropy alloys, Control of multiphase microstructures with case studies, hierarchical microstructures, composites; adaptive microstructures.

Surendra Kumar Makineni

References :

- R E Reed-Hill and R Abbaschian: Physical Metallurgy Principles, P.W.S-Kent, 1992.
- David A Porter, K E Easterling, Phase transformations in metals and alloys, Chapman & Hall, 2nd edition, 1992
- Ian Polmear, Light Alloys, 4th edtion, Butterworth-Heinemann, 2006
- Roger C Reed, The Superalloys: Fundamentals and applications, Cambrige university press, 2006
- B S Murthy, J W Yeh, S Ranganathan, P P Bhattacharjee, High entropy alloys, 2nd Edition, Elsevier, 2019

MT 231 (JAN) 3:0

Interfacial Phenomena in Materials Processing

Materials and surfaces, Adsorption from solution, Thermodynamics of adsorption - surface excess and surface free energy, Gibbs equation, adsorption isotherms, wetting, contact angle, Young's equation, Monolayer and interfacial reactions, Electrical phenomena at interfaces, electrochemistry of the double layer, electrokinetics, flocculation, coagulation and dispersion, Polymers at interfaces, Emulsions. Applications in Materials Processing.

Ashok M Raichur

References :

• Jacob N. Israelachvili, Intermolecular and Surface Forces, Academic Press, 3rd edition, 2011 A.W. Adamson and A. P. Gast, Physical Chemistry of Surfaces, Wiley Interscience, New York, 1996 Paul Hiemenz and Raj Rajagopalan, Principles of Colloid and Surface Chemistry, CRC Press, 3rd edition, 1997

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 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, Introduction to FEM and its applications to fracture mechanics, Indentation failure, Environmental aspects of failure, Thermal stresses, Cyclic Fatigue, Methods to measure toughness.

Praveen Kumar, 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 257 (JAN) 3:0

Finite Element Method for Materials Engineers

This course has been specially designed for those students, who did not get a chance to study FEM during undergrad, but want to use FEM as a tool to gain some insight into their project/research problems. The syllabus includes the following: Quick recap of relevant mathematical concepts. Introduction to fundamentals of elasticity and plasticity. Crystal plasticity. Philosophy of FEM. Fundamentals of FEM, such as concepts of meshing, stiffness matrix, interpolation functions. Residual methods, Rayleigh - Ritz method, Galerkin method. 1-D, 2-D and 3-D example problems in elasticity and heat transfer. Solving linear and non-linear structural, thermal and electrical problems using a commercial FEM software (mostly, ANSYS). Finite element crystal plasticit

Praveen Kumar

References :

• Praveen Kumar,Cook, R. D., et al, Concept and Applications of Finite Element Analysis, John Wiley & Sons, 2002 (IV Edn).1.O.C. Zienkiewicz,,Reddy J. N. An Introduction to Finite Element Method, Tata McGraw-Hill, 3rd Edn., 2005.

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,Lecturenotes,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

Centre for Product Design and 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		
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

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

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

Dibakar Sen, Ashitava Ghosal, Gurumoorthy B

Pre-requisites :

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

MN 206 (AUG) 0:28

Final Project

Each project will be offered to be carried out in groups of 2-3 students. The project will involve an in-depth development or in-depth study in an area in smart manufacturing.

Satish V Kailas, Dibakar Sen, Amaresh Chakrabarti, Gurumoorthy B, Satyam Suwas

Pre-requisites :

• Completed all ten courses mandatory for MTech Smart Manufacturing programme in its first and second terms.

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 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,SeventhEdn,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,BuxtonB."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 Definition and Classification, Bioethics and Privacy, 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, Biocompatibility and Biomaterials Testing, Clinical Trails, Digital Healthcare, Medical Records and Telemedicine. The course will include guest lectures by healthcare professionals giving exposure to unmet needs in the healthcare technologies and systems.

Manish Arora

References :

- B Ravi, The Essence of Medical Device Innovation, 2018, The Write Place, ISBN(13): 9789387282186
- Paul H king, Richard C. Fries, Arthur T. johnson, Design of Biomedical Devices and Systems. Third edition, ISBN 9781466569133,
- Peter J. Ogrodnik, Medical Device Design:Innovation from Concept to Market, Academic Press Inc; ! edition(2012), ISBN-10:0123919428,
- Stefanos Zenios, Josh Makower, Paul Yock, Todd J. Brinton, uday N. Kumar, Lyn Denend, Thomas M. Krummel,,Biodesign: The Process of Innovating Medical Technologies, Cambridbge University press; 1 edition(2009), ISBN- 10:0521517427

PD 239 (AUG) 0:3

Design and Society

Independent study/research on a chosen topic by students under the supervision of faculty members. Presentation of seminar on work done. The course also includes invited seminars on various aspects of product design and marketing issues. The focus is on real life situations from practicing professionals.

Dibakar Sen

Centre for Sustainable Technologies

ST 210 (AUG) 3:1

Principles and Applications of GIS and Remote Sensing

Key concepts and principles of remote sensing, GIS and digital image processing. Tools to address environmental problems. Roles of professionals in managing environment in their respective areas.

Ramachandra TV

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 216 (AUG) 3:0

Physics in Experiments with Classical Statistics

Dimensional Analysis: Buckingham pi theorem, non-dimensional groups, physical similarity, functionalities, scaling (with single and multiple independent groups), intermediate asymptotics; Probability: history, gaming, origin of random number, Bernoulli trials, binomial theorem, normal distribution; Curve fitting: regression and theory of splines; Classical Statistics: origin, Galton table- Darwinism; Karl Pearson: large sample studies, Pearson type distribution curves, Chi-square variance and limitations; William Gosset: small sample study, probable error of means, correlation coefficient, z statistics, Barley experiments, Fischer: degree of freedom, z to t statistics for small samples, Rothamsted agricultural experiments, analysis of variance, fundamentals of experimental designs, maximum likelihood, inductive reasoning; Uncertainty Analysis: Moffat's single sample theory in experiments; Engineering and Science problems: (hydrology, hydropower, turbomachinery, biology, chemistry, macroeconomics); Laboratory work (hydroloop and field measurements).

Punit Singh

References :

• [1] Barenblatt. G. I, 'Scaling', Cambridge Texts in Applied Mathematics, (2003) [2] Holman J. P., Experimental Methods for Engineers, Mcgraw-Hill Series in Mechanical Engineering, Eight Edition, (2011) [3] Grinstead M. C., Snell L. J., 'Introduction to Probability', 'American Mathematical Society', (1991) [4] Moffat, R. J., 'Contributions to the Theory of Single-Sample Uncertainty Analysis', J. Fluids Engineering, 250/Vol. 104, June (1982) [5] Bernard J. Norton, 'Karl Pearson and Statistics: The Social Origins of Scientific Innovation', Social Studies of Science. 8 (1): 3–34, (1978) [6] Student-Gosset, 'The Probable Error of a Mean', J. Biometrika, (1908) [7] Pearson E.S, 'Student: a statistical biography of William Sealy Gosset', Oxford University Press, (1990) [8] Rao C. R., 'Fisher R. A.: The Founder of Modern Statistics, Statistical Science, Vol. 7, No. 1, 34-48, (1992)

Pre-requisites :

• Mathematics (12 grade and above); Interpreting physical phenomena; Conversant with measurement, experimental and field studies

ST 217 (AUG) 3:1

Field hydrology, river engineering and basin studies

This course is an integrated package that aims to map both perennial and semi-perennial surface flows in Bastar region of Chhattisgarh state using information of rainfall, topography, surface flows and sub-surface water dynamics with an aim to create a sustainability of water resources management. A non-intrusive aquifer investigation and time scale studies of under-ground gradient towards the valleys is envisaged. Origin of springs from where these streams have evolved will be studied and along with longitudinal surface gradient understanding both its influent and effluent relationship with groundwater. The tribal settlements, their water needs for irrigation and drinking water using surface water flows and natural hydropower (non-electricity) or renewable energy-based pumping will be studied. Options of sub-surface storage (provided as natural aquifer is identified) as well as surface water storage will be studied over the entire topography of Bastar region. Pumped storage for electricity and water requirements will be envisaged for regions that are not in the vicinity of streams. Ecological preservation interfaced with meeting the local needs will be stressed. Further, river morphology and sediment behavior will be investigated for any created obstruction of flow (either diversion of weir or riverbed foundations structure that may rise during activities). Overall modelling and sustainability with both waterpower and other renewable energy sources will be the objective.

Punit Singh

Centre for Earth Sciences

The Centre for Earth Sciences offers three post-undergraduate courses: (i) Ph.D., (ii) M.Tech. (Research) and (ii) M.Tech. in Earth Sciences

The Ph.D. students can take any of the courses offered in the department as well as in other department after consulting with their Ph.D. supervisor. Students with a B.Tech./ M.Sc. degree must finish 24 credits while students with an M.Tech. degree must finish 12 credits. M.Tech. (Research) students can take any of the courses offered in the department as well as in other department after consulting with their Ph.D. supervisor.

M.Tech. students have to complete 64 credits in two years. Students must take all 8 'hard core' courses (total 24 credits) listed below. In addition they must take 5 elective courses (15 credits) out of which 3 courses (9 credits) must be from the elective courses listed below. The M.Tech. project has 25 credits.

M Tech Programme in Earth Science
Duration: 2 years: 64 Credits

Hard Core: 24 Credits (All courses are mandatory)

ES 203 3:0 Introduction to Petrology (AUG)
ES 204 3:0 Origin and Evolution of the Earth (AUG)
ES 205 3:0 Mathematics for Geophysicists (AUG)
ES 206 3:0 Solid Earth Geophysics (AUG)
ES 215 3:0 Introduction to Chemical Oceanography (AUG)
ES 201 2:1 Introduction to Earth System Science (JAN)
ES 217 3:0 Fundamentals of Geophysics (JAN)
ES 207 0:3 Earth Science Laboratories (JAN)

Electives: 15 Credits of which at least 9 credits must be from among the group electives listed below.

ES 208 3:0 Mantle Convection (JAN)
ES 209 3:0 Biogeochemistry (AUG)
ES 211 3:0 Applied Petrology (JAN)
ES 212 3:0 Fluid dynamics of planetary interiors (JAN)
ES 213 3:0 Isotope Geochemistry (JAN)
ES 216 3:0 Advanced Chemical Oceanography (JAN)
CE 247N 3:0 Remote Sensing and GIS for Water Resources & Environmental Engineering (JAN)

Project: 25 Credits

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 206 (AUG) 3:0

Solid Earth Geophysics

Earth's internal structure: composition vs mechanical properties, Geoid, GIA and viscosity, Stress and Strain from seismology perspective, Theory of Elasticity, Wave mechanics, Seismic tomography, Earth's free oscillations, Phase transformations within the Earth, Introduction to mineral physics, Spherical harmonics, Heat: conductive, convective and radioactive heat flow, Heat flow in oceans and continents, Half space vs plate cooling models, Convection within mantle and core, Structure of mid-oceanic ridge system, Strength of continental lithosphere

Attreyee Ghosh

References :

- Fowler, C.M.R., The Solid Earth: An Introduction to Global Geophysics, 2nd edition, Cambridge University Press, 2005; Turcotte, D., and Schubert, G., Geodynamics, Cambridge University Press, 2002, Turcotte, D., and Schubert, G.

ES 215 (AUG) 3:0

Introduction to Chemical Oceanography

The concentration, isotopic composition, and distribution of the dissolved and particulate components of seawater tells the story of a fascinating and complex interplay between tectonic uplift, chemical and physical weathering, climate, biology, ocean circulation, and intrinsic properties of elements and ions in solution. In this series of lectures we will try to understand what controls the chemistry of seawater from a regional to global scale and what is the interplay between climate and ocean chemistry. The major themes that will be covered are: (a) concentration, spacio-temporal distribution, and the residence time of the dissolved components of seawater; (b) air–sea exchange of gases; (c) steady state and non-steady state oceanic cycle of dissolved components; (d) estimation of oceanic mixing time utilising natural and artificial tracers; (e) influence of biology on ocean chemistry - carbon pumping from surface to deep; (f) the role deep ocean carbon reservoir in controlling climate.

SambuddhaMisra

References :

- Tracers in the Sea - Broecker and Peng, LDGEO Press, 1983
- An Introduction to the Chemistry of the Sea - Michael E. Q. Pilson, Cambridge University Press

ES 201 (JAN) 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 207 (JAN) 0:3

Earth Science Laboratory

This course is designed for students pursuing M.Tech. in Earth Science. Topic covered are: Geochemical techniques; mineral separation; Stable isotope analysis using isotope ratio mass spectrometer, sample preparation and analysis, data reduction, sedimentological techniques; computational techniques.

SambuddhaMisra, Ramananda Chakrabarti, Binod Sreenivasan, Attreyee Ghosh, Prosenjit Ghosh, Kusala Rajendran, Sajeev Krishnan

References :

- Reed, S.J.B., Electron Microprobe Analysis and Scanning Electron Microscopy in Geology, Cambridge University Press, 2010
- Handbook of Stable Isotope Analytical Techniques, Pier A. de Groot, ISBM 978-0-444-51114-0, Elsevier Science 1258, 2004
- Techniques in sedimentology edited by Maurice Tucker, Black Scientific Publications, 1988

Pre-requisites :

- Student must have credited ES 201, 203, 204

ES 208 (JAN) 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 211 (JAN) 3:0

Applied Petrology

Applied Petrology

Sajeev Krishnan

ES 212 (JAN) 3:0

Fluid dynamics of planetary interiors

Basic fluid dynamics - Navier-Stokes equation, vorticity equation, Kelvin's circulation theorem, energy and dissipation, helicity. Rotation - Coriolis force, linear inertial waves, formation of Taylor columns, geostrophy, quasi-geostrophic approximation. Stratification - Gravity waves, effect of rotation, Braginsky's theory of stratified outer core of the Earth. Magnetic fields - Magnetohydrodynamic (MHD) equations, Lorentz force, low and high magnetic Reynolds number, Alfven waves, Magnetic-Coriolis (MC) waves, Rayleigh Benard convection with magnetic field and rotation, MHD of planetary cores. Turbulence - Richardson's cascade, overview of classical theories, 2D turbulence, turbulence under moderate and rapid rotation, MHD turbulence, different length scales in planetary core turbulence.

Binod Sreenivasan

References :

- Davidson, P.A., Turbulence in rotating, stratified and electrically conducting fluids, Cambridge University Press, 2013
- Acheson, D.J., Elementary fluid dynamics, by, Oxford University Press, 1990.
- Journal papers

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, Isotopes - principles and applications 3rd edition, Wiley-India Edition

ES 216 (JAN) 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.

SambuddhaMisra

References :

- (1) Tracers in the Sea – Broecker and Peng, LDEO Press, 1983 (2) CO2 in Seawater – Zeebe and Wolf-Gladrow, Elsevier Oceanography Series, 2003 (3) Isotope Geochemistry – William White, Wiley Blackwell, 2015

ES 217 (JAN) 3:0

Fundamentals of Geophysics

Structure of the Earth's interior - density, seismic velocity, pressure and temperature dependence. Earth's magnetic field - the dynamo process, paleomagnetism, geomagnetic reversals. Plate motions - absolute and relative motions, Euler poles, triple junction, simple calculations. Elements of potential field theory and applications, Earth's gravity field, geodesy, isostasy, Plate tectonics, earthquake and faulting processes, types of faults and relation to stress fields, moment tensors and earthquake focal mechanisms

Binod Sreenivasan, Attreyee Ghosh

References :

• Fowler, C.M.R., The solid earth: An Introduction to Global Geophysics, Cambridge University Press, 2005. W. Lowrie and A. Fichtner, Fundamentals of Geophysics (3rd edition), Cambridge University Press, 2020.

ES 299 (JAN) 0:25

Dissertation Project

MTech thesis dissertation

SambuddhaMisra, Ramananda Chakrabarti, Binod Sreenivasan, Attreyee Ghosh, Prosenjit Ghosh, Kusala Rajendran, Sajeev Krishnan

Division of Interdisciplinary Sciences

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, Sustainable Transportation and Urban Planning, Department of Management Studies, Robert Bosch Centre for Cyber Physical Systems, Supercomputer Education and Research Centre and Interdisciplinary Mathematical Sciences. 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	Centre for Biosystems Science & Engineering
CP	Robert Bosch Centre for Cyber Physical Systems
ER	Interdisciplinary Centre for Energy Research
DS	Department of Computational and Data Sciences
MG	Department of Management Studies
MS	Interdisciplinary Mathematical Sciences
NE	Centre for Nano Science and Engineering
UP	Centre for 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. Navakanta Bhat
Dean
Division of Interdisciplinary Research

BioSystems Science and Engineering

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 202	3:0	Thermodynamics and Transport in Biological Systems
BE 209	1:0	Digital Epidemiology
BE 210	3:0	Drug Delivery
BE 212	1:0	Research Communications

BE 202 (AUG) 3:0

Thermodynamics and Transport in Biological Systems

Transport : Introduction to biological flow systems, passive & active transport, Heat, Mass and Momentum Transfer with Case Studies. This part will be taught by Dr Priya Gambhire (Inspire Faculty, BSSE, IISc) Thermodynamics: First and Second Laws, Heat and Work Interactions, Application to Open Systems, Lattice Models and Binding Equilibria, Regular Solution Theory, Phase and Reaction Equilibria, Membrane Biophysics. This part will be taught by Prof. Ganapathy Ayappa (Chemical Engineering, IISc)

Ganapathy Ayappa

References :

- Transport Phenomena, R. B. Bird, W. E. Stewart, E. N. Lightfoot, Wiley India, 2006.
- Transport Phenomena in Biological Systems by G.A Truskey, F. Yuan and D. F. Katz, Pearson Prentice Hall, 2010.
- Introduction to Chemical Engineering Thermodynamics: Special Indian Edition by J. M. Smith, H.C. Ness, M. Abbott and B Bhatt
- Biological Thermodynamics, by Donald T Haynie Second Edition, 2008, Cambridge University Press.

Pre-requisites :

- Some background in basic heat, mass and momentum preferred. Undergraduate level thermodynamics.

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

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. The sudden and savage nature of the ongoing COVID-19 pandemic has certainly caught everyone's attention. The fact that it has happened when the globe is so well connected thanks to information technology has made epidemiologists of just about anyone who has some mathematical ability and appreciation of infectious disease dynamics. However, there are some serious mathematicians and data scientists who have been interested in the power of computational epidemiology in counterfactual reasoning and in the predictive power of data driven models. The prediction by the Global Virome Project that we could have around three zoonotic episodes a year that would have pandemic potential implies that we do need the best minds to help us prepare for the next one. Previous course offerings are archived at the website http://healtheatmapindia.in/digita-epidemiology. Syllabus: Introduction to epidemiology; SIR modelling, from the microscopic to the macroscopic, herd immunity; Compartment models (location compartments, age compartments, disease stage compartments), impact on herd immunity, social distancing, masks; Parameter fitting for SIR models; Clinical studies and disease biology. Agent-based models - general description, network generation and computational aspects, contact tracing, transport, calibration, validation. Data-driven and mathematical modeling for response is going to be specific to the stages of a pandemic – pre-pandemic, acceleration, mitigation, suppression and post-pandemic (peace time). Instructor: This course will be taught by Prof. Vijay Chandru (vijaychandru@iisc.ac.in), Adjunct Professor, BSSE

Narendra M Dixit

References :

- Epidemiology, A Very Short Introduction, Rodolfo Saracci, Oxford University Press
- Statistical models in Epidemiology, D. Clayton and M. Hills, Oxford University Press
- Viruses, Pandemics, and Immunity, A K Chakraborty and A Shaw, Illustrated by P J S Stork, MIT Press 2020
- Data-driven modeling for different stages of pandemic response
- Aniruddha Adiga, Jiangzhuo Chen, Madhav Marathe, Henning Mortveit, Srinivasan Venkatramanan, Anil Vullikanti, September 2020 https://arxiv.org/abs/2009.10018
- City-Scale Agent-Based Simulators for the Study of Non-Pharmaceutical Interventions in the Context of the COVID-19 Epidemic https://arxiv.org/abs/2008.04849

Pre-requisites :

- The only prerequisite for this course is a reasonable preparation in computational mathematics – modelling and analysis

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

Pre-requisites :

- Open for all PhDs. Undergraduates must have finished two years of UG curriculum

BE 214 (AUG) 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.

Siddharth Jhunjhunwala, Ananthasuresh G K

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

Pre-requisites :

- Two course in mathematics at the undergraduate level
- For undergraduates interested in this course, they must have completed 2 years in the IISc undergraduate program

BE 203 (JAN) 0:1

Bioengineering Practicum 1

Bioengineering Practicum provide bioengineering laboratory experience to enable the student to do practical work in a particular field of specialization by working in the laboratories of the thesis adviser(s). The student is expected to learn the experimental techniques and practical methods pertaining to the research topic undertaken. The student is also expected to understand his/her thesis project and should be able to explain its significance in the field. They are also expected to have started performing research in the lab and understand the principles behind the experiments being conducted. The evaluation will be based on written reports and oral presentation. 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 thesis research. The students are advised to take the initiative to thoroughly understand all the related material of each and every technique and experiment they learn and perform.

Rachit Agarwal, Narendra M Dixit

Pre-requisites :

- Admission into BSSE PhD. program

BE 204 (JAN) 0:1

Bioengineering Practicum 2

Bioengineering Practicum provide bioengineering laboratory experience to enable the student to do practical work in a particular field of specialization by working in the laboratories of the thesis adviser(s). The student is expected to learn the experimental techniques and practical methods pertaining to the research topic undertaken. The student is also expected to understand his/her thesis project and should be able to explain its significance in the field. They are also expected to have started performing research in the lab and understand the principles behind the experiments being conducted. The evaluation will be based on written reports and oral presentation. 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 thesis research. The students are advised to take the initiative to thoroughly understand all the related material of each and every technique and experiment they learn and perform.

Rachit Agarwal, Narendra M Dixit

Pre-requisites :
- Admission into the BSSE PhD program

BE 207 (JAN) 3:0

Mathematical Methods for Bioengineers

Linear algebraic equations; Existence and uniqueness of solutions; LU factorization; Linear least squares; Eigenvalues and eigenvectors; QR iteration; Nonlinear equations; Fixed point iteration; Optimization methods; Nonlinear least squares; Ordinary differential equations; First and second order ODEs; Euler, RK4, and predictor-corrector methods; Basic probability and statistics; Hypothesis testing; Student's t-test; ANOVA; Non-parametric tests

Mohit Kumar Jolly, Narendra M Dixit

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.
- GDGopen and J Swan (1990) The Science of Scientific Writing. American Scientist. 78:550-558

BE 213 (JAN) 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, the enzyme electrode, chemistries for the detection of proteins/polypeptides and nucleic acids; microfluidics and its applications in biosensing; fluid dynamics and chemical kinetics of microfluidic biosensors; introduction to point-of-care biosensing; lateral flow assays, systems engineering approach in designing sample-in-answer-out biosensors

Bhushan J Toley, Mohit Kumar Jolly

ENERGY RESEARCH

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

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,Basicalgorithms,Consent of instructor

DS 263 (AUG) 3:1

Video Analytics

Revisit to Digital Image and Video Processing, Camera Models, Background Modelling, Object Detection and Recognition, Local Feature Extraction, Biologically Inspired Vision, Object Classification, Segmentation, Object

Tracking, Activity Recognition, Anomaly Detection, Handling Occlusion, Scale and Appearance changes, Other Applications.

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 :
- Image Processing, Probability, Linear Algebra

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.

Phani Sudheer Motamarri

Pre-requisites :
- Basics of matrix algebra,Basicprogramming,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.

Sashikumaar Ganesan

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.

SoumyenduRaha

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 250 (JAN) 3:1

Multigrid Methods

Classical iterative methods,convergence of classical iterative methods,Richardson iteration method,krylov subspace methods: Generalized minimal residual (GMRES),Conjugate Gradient(CG),Bi-CG method.GeometricMultrigrid Method: Grid transfer,Prolongation and restriction operators, two-level method, Convergence of coarse grid approximation,Smoothing analysis. Multrigrid Cycles: Vcycle, W-cycle, F-cycle, convergence of multigrid cycles, remarks on computational complexity. Algebraic Multigrid Method:Hierarchy of levels, Algebraic smoother, Coarsening, interpolation, remarks on parallel implementation.

Sashikumaar Ganesan

Pre-requisites :

- Good Knowledge of Linear Algebra and/or consent from the instructor.

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,Literaturereview,Clear idea about the research project

DS 323 (JAN) 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 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.

SoumyenduRaha, Deepak Subramani

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

Nanoscience and Engineering

M Tech Degree Programme

Duration: 2 years

Departmental Core 11 credits

Course Credits &Title

NE 200 2:0 Technical Writing and Presentation
NE 201 2:1 Micro and Nano Characterization
NE 202 0:2 Micro and Nano Fabrication
NE 203 3:0 Advanced micro- and nanofabrication technology and process
NE 250 1:0 Entrepreneurship, Ethics and Societal Impact

Project

NE 299	**0:27 Project Work**
	0:03 May-July
	0:09 August–December
	0:15 January June

Electives: The balance of 26 credits to make up the minimum of 64 credits required to complete the M Tech Programme at CeNSE has to be taken by choosing elective courses from within/outside the department with the approval of the Faculty advisor such that at least 4 elective courses have to be chosen from CeNSE.

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, SushobhanAvasthi

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

Akshay K Naik, Shivashankar S A

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,ACelectrokinetics 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)
- MiltonOhring, 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.

Akshay K Naik, Manoj Varma

Pre-requisites :

- Lecture notes and hands-on training manuals,-,-

NE 202 (JAN) 0:2

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, SushobhanAvasthi

Pre-requisites :

- NE203

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 223 (JAN) 2:1

Analog Circuits and Embedded System for Sensors

Basic Circuit Analysis and Passive Components; Introduction to semiconductor devices and circuits involving Diodes, BJT, MOSFET and JFET; Opamp circuits: Transimpedance amplifier, Instrumentation amplifier, Comparator, Precision DMM application; Tradeoffs between power, noise, settling time and cost; Survey of sensors and their datasheets; Filters and Oscillators; State Machines, Digital IO, 555 timer, Latch, Flip-flops, Divide by N; Microcontroller programming; Communication protocols for sensor interfacing. Will include (at least) weekly lectures, labs and a final project. Textbooks: Paul Horowitz, Winfield Hill, “Art of Electronics”, Cambridge University Press, 3rd Edition, 2015. J. Edward Carryer, Matthew Ohline and Thomas Kenny, “Introduction to Mechatronic Design”, Pearson Education India, 1st International edition, 2012. Jeremy Blum, "Exploring Arduino: Tools and Techniques for Engineering Wizardry", Wiley, 2013

Saurabh Arun Chandorkar

Pre-requisites :

- 1st/2nd year undergraduate level Basic Circuits course,1st/2nd year undergraduate level Basic Programming course

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.,Researcharticles,,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 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,-,-

Dept of Management Studies

MasterofManagement(M.Mgt)Program

Duration:2years

HardCore:24credits

MG201 3:0 Managerial Economics
MG211 3:0 HumanResourceManagement
MG212 2:1 BehavioralScience
MG221 2:1 AppliedStatistics
MG232 3:0 PrinciplesofManagement
MG241 3:0 MarketingManagement
MG251 3:0 Finance&Accounts
MG261 3:0 OperationsManagement

StreamCore:12Credits(tobechosenfromeitheroneofthetwostreams)

Stream1:BusinessAnalyticsStream

MG223 3:0 AppliedOperationsResearch
MG225 3:0 DecisionModels
MG226 3:0 TimeSeriesAnalysisand Forecasting
MG265 2:1 DataMining

Stream2:TechnologyManagementStream

MG271 3:0 TechnologyManagement
MG274 3:0 ManagementofInnovationand IntellectualProperty
MG281 3:0 ManagementofTechnologyfor Sustainability
MG298 2:1 EntrepreneurshipforTechnologyStart-ups

Electives:12credits

Project: :**MG2990:16ManagementProject**

SummerInternship: Nocredits.Everystudentisrequiredtospendaminimumofeightweeksinanidentifiedindustrialenterpriseorpublicsectororganizationduringthesummerperiodafterthefirsttwosemesters.Alternativelystudentshavetheoption togetexposuretobusinessincubators,venturecapitalfirmsandsuccessfulstart-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,andCases,WW Norton

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.

AnjulaGurtoo

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 258 (AUG) 3:0

Financial instruments and risk management strategies

The purpose of this course is to introduce various financial instruments, such as futures, options, and swaps associated with different asset classes, such as interest rates, forex and stocks. The course covers the principles of derivative pricing with an introduction to the Black Scholes framework. We cover some basic hedging strategies including delta hedging to manage derivative risks. Basic numerical schemes for derivative pricing, bootstrapping of interest rate term structure are also covered.

Shashi Jain

References :

- Options, Futures, and Other Derivatives (John Hull). Pearson.

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

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.

Parthasarathy Ramachandran

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,JohnNeter& 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,andWilliams,An Introduction to Management Science: Quantitative Approaches to Decision Making,11th Edition

MG 226 (JAN) 3:0

Advanced Analytics

Review of multiple linear regression - variable selection, regression diagnostics. Introduction to generalized linear models - likelihood inference, deviance, model checking. Logistic regression - models for log-odds, estimation and hypothesis testing, residual analysis and goodness-of-fit, polytomous and ordinal responses, propensity scores. Survival analysis - censored data, models and estimates for survival functions and hazard functions, proportional hazards and partial likelihood, semi-parametric models for regression, inference and model checking. Multivariate ananlysis – multivariate Normal distribution and its properties, one two and multisample problem for multivariate Normal distribution, multivariate analysis of variance, principal component analysis, factor analysis.

Mukhopadhyay C

References :

• Hosmer David W. and Lemeshow Stanley. Applied Logistic Regression. Third Edition. 2013. Wiley. Klein Jhohn P. and Moeschbergerer Melvin L. Survival Analaysis: Techniques for Censored and Truncated Data. Second Edition. 2003. Springer. Johnson Richard A. and Wichern Dean W. Applied Multivariate Statistical Analysis. Sixth Edition. 2007. Pearson Michael H. Kutner, Christopher J. Nachtsheim, John Neter& William Li, Applied Linear Statistical Models, McGraw-Hill International Edition, Fifth Edition, 2005.

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 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.

AnjulaGurtoo

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

CYBER PHYSICAL SYSTEM

CP 212 (AUG) 2:1

Design of Cyber-Physical Systems

This course will be taught jointly with Dr. Ashish Joglekar and Darshak Vasavada. This is an interdisciplinary course on the design of cyber-physical systems, inviting students from all the departments. It provides an in-depth exposure to various elements of a CPS: the microprocessor, interfacing physical devices (analog and digital) and control systems basics. This course uses a practical approach and involves significant programming. Syllabus: 1. Microprocessor system 2. Interfacing physical devices 3. Control system basics 4. EMI/EMC considerations 5. Network connectivity

Bharadwaj Amrutur

References :

- Embedded Systems: a CPS approach: Lee and Seshia
- Embedded Systems - Shape the World: Valvano and Yerraballi
- Basics of Microprocessor Programming: Darshak Vasavada and S K Sinha

Pre-requisites :

- C programming
- Familiarity with any microprocessor and analog/digital circuits

CP 214 (AUG) 3:1

Foundations of Robotics

NOTE: This course is cross-listed with CSA (soft core for CSA) Motivation and objective: As we see an increasing use of industrial and service robots around us, there is a need for development of new skills in the field of robotic systems. More importantly, there is a need for development of new expertise in controllers, systems, sensors and algorithms that are tailored for the domain of robotic systems. Therefore, the objective of this course is to serve as an introductory robotics course for EECS students with little/no background in mechanical systems. The course will first build the necessary mathematical framework in which to understand topics relevant to fundamentals of mechanical systems. Some of the topics are center of gravity and moment of inertia, friction, statics of rigid bodies, principle of virtual work, kinematics of particles and rigid bodies, impacts, Newtonian and Lagrangian mechanics. With these fundamentals, the course will focus on topics like rigid body transformations, forward and inverse kinematics of manipulators, and forward and inverse dynamics of manipulators. Towards the end of the course advanced topics such as rigid body collisions, and hybrid dynamical systems will also be covered. Syllabus: Free-body diagrams, constraints, friction, center of gravity and moment of inertia. Virtual displacement, principle of virtual work, potential energy and equilibrium. Types of motion, force, acceleration. Work and energy, impulse and momentum, impact. Configuration space, task space, rigid body transformations. Manipulator kinematics, forward and inverse kinematics. Forward and inverse dynamics. Hybrid systems, introduction to walking robots.

Shishir N Y

References :

- Ruina, Andy and Pratap, Rudra, Introduction to Statics and Dynamics, Oxford University Press, 2011.
- Murray, Li and Sastry, A Mathematical Introduction to Robot Manipulation, CRC Press, 1994
- A. Ghosal, Robotics: Fundamental Concepts and Analysis, Oxford, 2006

Pre-requisites :

- None

CP 311 (AUG) 2:1

Dynamics and Control of Smart Materials

This course will be taught jointly with Josephine Selvarani Ruth D Syllabus: Introduction to smart/intelligent materials, artificial intelligence vs embedded inherent intelligence smart systems, definitions and implications, components of smart systems, role of smart materials in developing active intelligent systems. Dynamics of high bandwidth low strain smart systems (piezoelectrics, magnetostrictive), types of piezoelectric materials, generator and motor principle, constitutive relationship, unimorph and bimorph actuators, design of sensing and actuating smart systems, application examples. Dynamics of high strain low bandwidth systems (shape memory alloys, electro-active polymers, magnetostrictive, electrostricitve), phase transformations, characteristics of SMA control, modelling approach, Design of actuators –damper, compliant, variable impedance actuator, self-sensing actuator, application examples. Design and control of hybrid smart systems (System identification, controller, MATLAB Simulink), Intelligent system design, factors to be considered in selection of smart materials to develop a smart systems, optimal placement, dynamics of smart hybrid system, modelling features, concepts of sensor –actuator integration, amalgamation of smart materials and control system. Shared sensing and actuation, self-sensing actuation, techniques of dual functionality, developing a smart device in a networking dual control loop systems. Laboratory experiments on the above topics

Bharadwaj Amrutur

References :

- Culshaw B., Smart structures and Materials, Artech house, 1996
- Leo, D.J. Engineering Analysis of Smart Material Systems, Wiley, (2007).
- Gauenzi, P., Smart Structures Physical Behaviour, Mathematical Modelling and Applications, Wiley, 2009
- Srinivasan A.V., Michael McFarland D., Smart Structure analysis and design, Cambridge University Press, 2001

Pre-requisites :

- Basic undergraduate engineering Courses

CP 314 (JAN) 3:1

Robot Learning and Control

NOTE: This course is cross-listed with E1 301 (soft-core at CSA) Motivation and objective: This graduate course will explore the new area of interaction between learning and control specifically applied to robotic systems, both from a foundational level together with a view toward application. The course will first build the necessary framework in which to understand robotic systems, including robot kinematics and dynamics, sensing and estimation, machine learning and control. With these fundamentals the course will focus on data driven approaches for control. Syllabus: Robot dynamics and kinematics, nonlinear control and stability, Lyapunov theory, PD control, reinforcement learning, imitation learning, model-based and model-free methods, impedance control, trajectory optimization, online learning.

Shishir N Y, Shalabh Bhatnagar

References :

- Sutton and Barto, Reinforcement Learning: An Introduction, MIT Press, 2017.
- S. Levine, Deep Reinforcement Learning.
- Murray, Li, and Sastry, A Mathematical Introduction to Robot Manipulation, CRC Press, 1994.
- Spong, Hutchinson and Vidyasagar, Robot Modeling and Conrol, Wiley, 2005.

Pre-requisites :

- E0 226 Linear Algebra and Probability or equivalent