भारतीय विज्ञान संस्थान

Scheme of Instructions

January-April 2026 Semester

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.

Please note that from this year, we are publishing the Scheme of Instruction (SoI) for the academic year in two parts. This being the first part (Part-A) that corresponds to the August semester courses, and the second one (Part-B) will be published in the beginning of January for the January semester courses. Both parts are being directly generated from the SAP-SLcM system, so that only the active courses for each semester are reflected. For students, who would like to get an idea of the January semester courses before January, they are encouraged to look at the previous years Scheme of Instruction, to get an idea of the courses that are likely to be offered in the January semester.

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. Very few selected 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 one 3-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 programmes and Master's programmes that are both course-based and research-based. Each course- based Master's programme consists of core courses, electives and a dissertation project. Details of the requirements can be found under the course listing of the departments or divisions that offer them. Student are assigned faculty advisors who 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 Information Handbook.

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 programmes have 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, the RTP consists of a minimum of 24 credits. Similar RTP requirements apply for students who upgrade or continue their registration from the Masters programmes of the Institute. For the research-based Master's degree, the RTP consists of minimum 12 credits. The Integrated PhD programme has 64 credits. Research students have the option of crediting courses beyond the RTP requirement 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.

Chair
Senate Curriculum Committee

Division of Biological Sciences

Preface

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

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

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

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

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

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

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

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

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

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

Prof. Usha Vijayaraghavan

Dean,

Division of Biological Sciences

DB 202 (JAN) 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.

Saskya Daly Van Nouhuys

Pre-requisites : None

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

DB 212 (JAN) 0 : 6

Biological Science

Aravind Penmatsa

Pre-requisites : None

References : None

DB 225 (AUG) 0 : 6

Project - II

Aravind Penmatsa

Pre-requisites : None

References : None

DB 327 (JAN) 0 : 6

Project- III

An independent research project to be conducted in the laboratory of a facultymember in the Division of Biology. It is desirable that the project be carriedout in the laboratory where Project II was conducted.

Aravind Penmatsa

Pre-requisites : None

References : None

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.

Balaji J,Shantanu P Shukla

Pre-requisites : None

References : None

DB 250 (JAN) 2 : 0

Research Applications of Flow Cytometry

Flow Cytometry, Flow Cytometry and Microscopy, Flow Cytometry: Problems, Parameters, Probes and Principles. Light and Matter, Optical Systems, Light Sources, Light Collection, Detectors, Flow Systems, Electronic Measurements, Analog Signal Processing, Digital Signal Processing, Performance: Precision, Sensitivity and Accuracy, Data Analysis, Computer Systems for Flow Cytometry, Compensation and Multiparameter Data Analysis, Flow Sorting, Extrinsic Parameters, Intrinsic parameters, Fluorescent labels and Protein dyes, Nucleic Acid dyes and uses, Measurement of cell surface and Intracellular Antigens, Signal Amplification and other techniques, Kinetic measurements and Functional Probes.

William Rasican Surin

Pre-requisites : None

References : Practical Flow Cytometry, Howard M Shapiro

Biochemistry

Preface

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.

Mahipal Ganji

Pre-requistes : None

References : None

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.

Patrick D Silva , Debabrata Laha , Payel Roy

Pre-requistes : None

References : None

BC 205 (JAN) 2 : 0

Fundamentals of Physiology and Medicine

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

Sandeep M Eswarappa , Ramray Bhat , Nikhil R Gandasi

Pre-requistes : None

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

BC 207 (JAN) 2 : 0

Proteomics in Practice

Utpal Tatu

Pre-requistes : None

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

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 , Kesavardana Sannula , Payel Roy

Pre-requistes :
Basic background in biology (class 12 level) is required. The course is open to undergraduates, masters, integrated PhD and PhD students.

References : None

BC 303 (JAN) 2 : 0

Single-Molecule Approaches in Biology

This course is designed to provide a holistic picture of microscopy, starting from traditional diffraction-limited imaging to advanced super-resolution imaging and single-molecule approaches and their applications in biology. The course will begin by introducing the basics of light microscopy and the limitations of traditional imaging techniques. We will explore the historical aspects of photon detectors, which are at the heart of microscopy. Various microscopy techniques will be introduced, including confocal two-photon, 4Pi, Total Internal Reflection Fluorescence, and Fluorescence Lifetime Imaging. We will cover both ensemble-averaging super-resolution techniques such as STED and SIM, as well as Single Molecule Localization Microscopy-based techniques like PALM, STORM, and PAINT. Additionally, the course will delve into the historical background of single-molecule imaging approaches and their evolution, while discussing the advantages and limitations of these methodologies. We will explore how these techniques can be utilized to measure individual enzyme kinetics, nucleic acid structure and dynamics, and protein-DNA interactions. Furthermore, we will examine how these techniques can be applied to investigate a wide range of biological phenomena, such as protein folding and chromatin structure.

Rahul Roy , Mahipal Ganji

Pre-requistes : None

References : 1) Microscopy Biophysics of DNA-Protein Interactions: From Single Molecules to Biological Systems by Mark C. Williams and L. James Maher III 2) Handbook of Single Molecule Biophysics by Peter Hinterdorfer and Antoine van Oijen 3) Handbook of Incident Light Microscopy, Carl Zeiss Corp. And 4) recent research publications

BC 212 (AUG) 3 : 0

Essentials in Cell Biology

- Membrane structure and composition, transport, and trafficking
- Breakdown of macromolecules and energy generation
- Cell Cycle and its regulation
- The cytoskeleton and its role in cell shape, movement and diseases.

Part I (UT) : How molecular cell biology as a field evolved, contributions of notable scientists, signal peptide concept with emphasis on Gunter Blobel's work, steps in protein processing in the RER and Golgi, including protein folding, oligomerization, intracellular protein trafficking including lysosomal targeting.

Part II (DPN): Cell isolation and culture including 2D and 3D systems, Flow cytometry and cell imaging techniques, post translation modification and diseases, Nitrosative stress and oxidative stress, Endocytosis and receptor biology, including transferrin and LDL, autophagy, protein degradation pathways: lysosomal and ubiquitin-dependent and selected Nobel prizes in Cell Biology.

Part III (SP): The Cell Cycle and Cytoskeleton: Replication and Division: Witness the intricate choreography of the cell cycle, where cells meticulously replicate their DNA and divide to create new daughter cells. Different Cell Cycle stages, Cell cycle checkpoints. Explore the basic principles and mechanisms of the cytoskeleton, the internal scaffolding that provides structure and facilitates movement within the cell. Basic mechanisms for cell growth, cell death, cell specialisation, cell motility and interactions between cells and explain how these together facilitate the development of a multicellular organism.

Part IV (PDS): (A) Mitochondria Biogenesis: Introduction to mitochondria structure & function, Experimental Approaches, Outer and Inner membrane machinery, IMS and Matrix machinery. Protein Transport pathways: Signal sequence dependent, Outer membrane translocation, IMS region, Inner membrane: Conservative and STOP and Transfer pathways. Membrane protein insertion & biogenesis, Physiological significance (B) Mitochondrial Dynamics: Introduction, Fusion Machinery: Mitofusins: Mfn1, Mfn2 and OPA1 Fission Machinery: Dynamin-Related Protein 1 and Fis1 and other players Cell biology of Fusion and Fission Mechanisms, Experimental approaches, Physiological relevance, Disease pathogenesis. (C) Mitochondrial movement and positioning in axons: Anterograde movement of mitochondria in neurons, microtubule motors in mitochondrial motility in neurons and other cell types, Regulation of interaction between motor molecules and the organelle, motor-independent mechanisms for mitochondrial motility, Pathogenesis of neurological diseases. (D) Cross talk between Mitochondria and other organelles: Mitochondria and ER contact sites, Mitochondria & ER communication, structure of MAMs, & ERMES, retrograde signalling, Mitochondria, Peroxisome & Nuclear cross talk, Experimental approaches, metabolic disorders.

Dipankar Nandi , Patrick D Silva , Saravanan Palani

Pre-requistes :
Basic background in biology (class 12 level) is required. The course is open to undergraduates, masters, integrated PhD and PhD students.

References : References:

1. Lodish et. al. Molecular Cell Biology. Seventh Edition. Freeman Press.
2. Alberts, Morgan et al., Essentials in Cell Biology. Fifth Edition.

Ecological Sciences

Preface

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

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.

K Praveen Karanth

Pre-requistes : None

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

EC 301 (AUG) 2 : 1

Animal Behaviour : Mechanisms and Evolution

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

Kavita Isvaran

Pre-requistes : None

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

EC 302 (AUG) 2 : 1

Plant-Animal Interactions (Ecology, Behaviour and Evolution)

The interaction between plants and animals as consumers, parasites and mutualists. This includes sensory mechanisms of detection and assessment and signalling; energetics of plant–animal interactions; nectar, floral and vegetative scents and pollen chemistry; mate choice in plants; evolution of floral and fruit traits; plant defenses; behavioural and physiological processes in generalist and specialist herbivores, pollinators and seed dispersers.

Saskya Daly Van Nouhuys

Pre-requistes : None

References : None

EC 303 (AUG) 2 : 1

Stochastic and Spatial Dynamics in Biology

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

Vishwesha Guttal

Pre-requistes : None

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

EC 305 (AUG) 2 : 1

Quantitative Ecology : Research Design and Inference

The scientific process in ecology; framing ecological questions; elements of study design; confronting ecological models with data; understanding the nature of data; statistical hypothesis testing; linear models, regression, ANOVA; generalised linear models; statistical modelling strategies.

Kartik Shanker , Umesh Srinivasan

Pre-requistes : None

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

EC 306 (JAN) 2 : 1

Advanced ecological statistics

This course will cover advanced topics in ecological statistics. We will beginwith a refresher on probability distributions, -hypothesis framework, point estimations and linear regression. We will then move on to advanced topics,which will include basics of theory, simulations as well as hands-on exercises in R programming language. Topics to be covered include Linear Models (ANOVA,ANCOVA, multiple regression, etc.), Generalised Linear Models (with examples of binary, proportion and count data; issues of zero inflation), Mixed effects models (linear and generalised linear models); Strategies for modelling and model selection criteria (AIC, etc). We will emphasise the role of theory in ecological hypothesis generation, study design and analyses. We will do this using simple examples of theories from population ecology (logistic model and harvesting models), behavioural ecology (foraging strategies, sex ratio, etc)and evolution (drift and selection).

Kavita Isvaran

Pre-requistes : None

References : None

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

Pre-requistes : None

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

EC 202 (AUG) 2 : 1

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

Pre-requistes : None

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 206 (JAN) 2 : 1

Evolutionary Genetics

This course will emphasise teaching genetic principles and evolutionary mechanisms that generate the stupendous complexity in nature. The course will begin with discussions on evolutionary cosmology, including the origin of the Universe, Solar System, Earth, and life on our planet as we know it. Following this would be a series of lectures explaining the genetic mechanisms that generate variation in nature and how evolution operates on it. The course will then introduce various tools of the trade, including ‘omics’ technologies and associated bioinformatics, that have made it possible to address broad, interesting, and challenging questions in diverse fields of biology, including ecology, evolutionary biology, genetics, and biomedical research. This course will end with discussions on other interesting topics, including evolutionary development, evolutionary medicine, human evolution, and broader applications of evolutionary reasoning.

The course will consist of lectures, discussions and hands-on bioinformatic practical sessions. Practical sessions will introduce students to various aspects of data acquisition, processing, and analyses, while theory classes will provide in-depth knowledge of the underlying principles. At the end of the course, a final examination will be conducted to evaluate student performances.

Kartik Sunagar

Pre-requistes : A basic understanding of genetics and molecular biology is desirable but not mandatory.

References : 1. Evolutionary biology. Douglas J. Futuyma (1998). 3rd Sinauer Associates Inc, Publishers, Sunderland. 2. Evolutionary Analysis, Fifth Edition by Jon Herron Scott Freeman. 3. Bioinformatics and Functional Genomics, Pevsner (3rd edition). 4. Practical Computing for Biologists, Haddock and Dunn.

EC 207 (JAN) 2 : 0

Scientific writing for ecologists

Over the course of the semester we will progress through the steps of writing a scientific paper. We will cover the concept of a story, and what is needed to draw readers in, keep them engaged, and educate them about the topic. We will also study the structure of a paper, and the purpose of each section in a paper, as well as the structure and purpose of individual paragraphs and sentences.
Each student will work on a manuscript draft through the semester. We will meet twice a week for one hour. The first hour will be a lecture and the second will be small group discussion and exercises. Students will work in stable groups of 3 to 4 through the semester. Between weekly meeting the students will revise their writing and critique work by others in their group.

Saskya Daly Van Nouhuys

Pre-requistes : Material prepared to write a manuscript for a scientific or popular audience.

References : Schimel, Joshua. Writing science: how to write papers that get cited and proposals that get funded. OUP USA, 2012.

Neuroscience

Preface

NS 201 (AUG) 2 : 0

Systems Neuroscience

Neuronal biophysics, sensation & perception, motor systems

Aditya Murthy , S P Arun , Supratim Ray

Pre-requistes : None

References **:**

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

Pre-requistes : None

References : None

NS 203 (AUG) 2 : 0

Cognitive Neuroscience

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

Sridharan Devarajan , Padmala Srikanth

Pre-requistes : None

References : None

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.

Kavita Babu , Arnab Barik

Pre-requistes : None

References : None

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

Pre-requistes : None

References : None

NS 212 (JAN) 2 : 1

Neural Signal Processing

Neuronal biophysics, sensation & perception, motor systems Biophysics and computational 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 and Granger causality.

Supratim Ray

Pre-requistes : None

References : Kandel, Schwartz and Jessell. Principles of Neural Science, 4th Edition. Buzsaki, G. (2006). Rhythms of the brain (Oxford University Press, USA). S. Mallat, A Wavelet Tour of Signal Processing- The sparse way, Elsevier, Third Edition, 2009

NS 303 (JAN) 3 : 0

Topics in Systems and Cognitive Neuroscience

This is mainly a paper reading course. Every week, students are given 2-3 papers to read, and these papers are critically discussed during the class. The class is divided into 3 modules that cover different aspects of sensory and cognitive neuroscience such as sensory encoding, perception and object recognition, attention, decision-making, motor systems, and cognitive control. They are also asked to write grant proposals based on the papers and topics that they have covered.

Aditya Murthy , S P Arun , Padmala Srikanth

Pre-requistes :

References : Original Papers

NS 304 (JAN) 3 : 0

Topics in Molecular and Cellular Neuroscience

Critical reading and grant writing on various topics in molecular and cellular neuroscience. This is an advanced graduate reading course focusing on historical and current papers relevant to the Developmental and Cellular Neuroscience, Neuronal Circuits, Synaptic Transmission and Learning and Memory. The module will consist of weekly readings as well as a grant proposal at the end. Typically the students will be provided with ~4-5 articles per topic for reading with the emphasis on the methods used in the field and the unanswered problems in the field. The course will have the following topics for the syllabus: i) Learning and Memory ii) Synaptic Physiology and Neuroanatomy iii) Developmental Neuroscience and Neural circuits governing behavior

Deepak Kumaran Nair , Arnab Barik

Pre-requistes :

References : Will be provide during the course. Research articles will be selected from the contemporary research and provided.

Microbiology and Cell Biology

Preface

MC 202 (JAN) 2 : 0

Developmental Genetics

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

Samay Ravindra Pande

Pre-requistes : None

References : 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,

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; Bac

Dipshikha Chakravortty , Amit Singh , Samay Ravindra Pande

Pre-requistes : None

References : "Stanier, R.V.,Adelberg E.A and Ingraham J.L., GENERAL MICROBIOLOGY, Macmillan Press, Fourth edition Westriech, G.A. and Lechmann M.D., MICROBIOLOGY,Macmillan Press, Fifth Edition Atlas R.M.,MICROBIOLOGY: FUNDAMENTALS AND APPLICATIONS, Macmillan Press Second Edition Goldsby, R. A.,Kindt T. J.,Osborne B. A., Kuby J.,IMMUNOLOGY, W. H. Freeman &

MC 206 (AUG) 2 : 0

RNA Biology

Mechanisms and machinery of transcription in prokaryotes and eukaryotes. RNAsplicing 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, andtheir 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.

Saumitra Das , Purusharth Rajyaguru , Shovamayee Maharana

Pre-requistes :

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

MC 208 (AUG) 2 : 0

Principles of Genetic Engineering

DNA, RNA, Proteins: composition, isolation, purification and quantification methods. Gene cloning, restriction and modification enzymes. PCR, RT-PCR, Site directed mutagenesis and Nucleic acid sequencing methods. Plasmid vectors including phagemid, cosmid for gene cloning and expression. Bacterial strains for Genetic engineering. Transformation, Transduction and Transfection methods. Preparation and characterization of DNA libraries. Nucleic acid Hybridization, nucleic acid-protein, Protein-protein interaction methods. Methods to modulate gene expression: SiRNA/shRNA technology. Lentivectors and Transduction. Viral genome engineering and applications in gene therapy and vaccines. Plant genetic engineering. Animal cloning and germline modifications. Genome editing by ZFN, TALEN. CRISPR/Cas Systems for DNA and RNA targeting. Genome wide CRISPR screening. Gene Drives and applications. Ethical and Safety issues of Genome editing

Shashank Tripathi , Naresh Loudya

Pre-requistes : None

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

MC 210 (JAN) 2 : 0

Molecular Oncology

The Biology of Cancer, 2nd Edition (2014) by Robert A. Weinberg

Sudha Kumari

Pre-requistes : None

References : 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; Cancer spread; metastasis; Cancer stem cells; Resistance to

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; Celldeath 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 Gangi Setty , Sachin Kotak

Pre-requistes : None

References : Molecular Biology of The Cell, Fifth edition, Alberts et al.

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 athogenesis;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.

Balaji Kithiganahalli , Dipshikha Chakravortty

Pre-requistes : None

References : (1) David G. Russell and Siamon Gordon,Phagocyte-Pathogen Interactions: Macrophages and the Host Response to Infection,ASM Press,2009. Knipe,D.M.~

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 signi ficance. 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.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.

Saumitra Das , Shashank Tripathi , Kesavardana Sannula

Pre-requistes : None

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 MarieSkalka, Lynn W. Enquist; ISBN: 978-1-683-67335-4.~

MC 216 (JAN) 1 : 0

Biological Safety: Principles and practices

1.The Microbiota of Humans and Microbial Virulence Factors 2. Indigenous Zoonotic Agents of Research Animals 3. Biological Safety Considerations for Plant Pathogens and Plant-Associated Microorganisms of Significance to Human Health 4.Laboratory-Associated Infections 5. Viral Agents of Human Disease: Biosafety Concerns 6. Emerging Considerations in Virus Based Gene Transfer Systems 7. Biosafety for Microorganisms Transmitted by the Airborne Route 8. Cell Lines: Applications and Biosafety 9. Allergens of Animal and Biological System

Amit Singh

Pre-requistes : None

References : Biological Safety: Principles and Practices, (2017), Dawn P. Wooley & Karen B. Byers

MC 215 (JAN) 2 : 0

Lysosomes and Autophagy

Lysosomes: Organelle contents and environment, functions, discovery of lysosomes and classical papers and experiments, cargo trafficking into out of lysosomes, position, contact and fusion with other organelles and lysoIP. Transcriptional regulation of lysosome biogenesis, spatiotemporal distribution of lysosomes within a cell, lysosome reformation, lysosomal turnover and exocytosis, lysosome as signaling hubs and nutrient sensor, lysosome cell death, dysfunction and associated diseases. Model systems to study lysosome biology and state of the art methods in monitoring lysosomal biology. Autophagy: Discovery of autophagy and classical papers and experiments. Principles and biogenesis mechanisms, types of autophagy, organelles specific autophagy, cross talk between lysosomes and autophagy, and autophagy modulation in diseases. Model systems to study autophagy, signaling transduction pathways that affect autophagy. State of the art methods in monitoring autophagy flux.

Subba Rao Gangi Setty

Pre-requistes :

None

References : 1. Lysosomes and Lysosomal Diseases (Methods in Cell Biology, Volume 126) by Platt & Platt, Publisher: Academic Press; 1st edition (February 19, 2015). Reviews: Platt et al., Nat. Rev. Dis. Primers (2018) and Ballabio and Bonifacino, Nat. Rev. Mol. Cell Biol. (2019).

MC 217 (JAN) 2 : 0

Fundamentals of Immunotherapy

1.Immunotherapy- Definition and history 2. Primer on the immune response to diseases- autoimmunity vs. immunosuppression 3. Introduction to various components of immunity 4.Primer on adaptive immune response: development, function, and regulation 5.Broad classes of immunotherapy-1 6.Broad classes of immunotherapy-2, 7.Checkpoint therapies 8.Antibody drug conjugates 9.Cancer vaccines 10.Protein and immune receptor engineering-1, 11.Protein and immune receptor engineering-2, 12.Innate immune response: development, function, and regulation 13.Inflammation and cell death in immunotherapy outcome-1, 14.Inflammation and cell death in immunotherapy outcome-1, 15.Immunotherapies targeting innate immune cells (macrophages & dendritic cells) 16.Immunotherapies targeting granulocytes and innate-like cells 17. Antigen-presenting cells and adjuvants - vaccines and immunotherapy 18.Immunoengineering-1: ex vivo manipulation of immune cells 19. Immunoengineering-2: in vivo manipulation of immune cells; nanotechnology and intratumoral delivery 20.Immunoengineering-3: Emerging areas in engineering immune cell

Kesavardana Sannula , Sudha Kumari

Pre-requistes :

None

References : 1.Review papers on specific topics 2.Textbook: Cancer Immunotherapy Principles and Practice Textbook, 2nd Ed. By Lisa H. Butterfield, Howard L. Kaufman, and Francesco M. Marincola. 3. Textbook: Cellular and Molecular Immunology by Pillai, Lichtman, and Abbas

MC 218 (AUG) 2 : 0

Advances in Molecular Biology

The course covers from the basic to the recent developemnts in the following topics: DNA structure, genome complexity, genome organization, DNA topology, DNA-protein interactions, chromatin structure and remodeling, DNA replication, RNA-Protein intearction, Transcription and its regulation, Mechanisms of DNA repair, RNA splicing, Catalytic RNAs, mRNA stability and editing, small mRNA mediated gene regulation, tRNA structure and function, Genetic code and its evolution, Translation regulation in eukaryotes and prokaryotes

Shovamayee Maharana

Pre-requistes :
Basic knowledge in General Microbiology and General Biochemistry

References : 1) Molecular Biology of the Cell (Latest Edition) by Bruce Alberts
2) Lewin's Genes XII by Jocelyn E Krebs, Eliott S Goldstein, Stephen T Kilpatrick
Unfortunately, I cannot add anything to SAP. The windows look inactivated.

Molecular Biophysics Unit

Preface

MB 201 (AUG) 2 : 0

Introduction to Biophysical Chemistry

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

Ashok Sekhar

Pre-requistes : None

References : None

MB 204 (AUG) 3 : 0

Molecular Spectroscopy and its Biological Applications

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

Siddhartha P Sarma

Pre-requistes : None

References : None

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 , Vidya Mangala Prasad

Pre-requistes :
Basic knowledge in matrix, probability theory, basic physics

References : None

MB 208 (JAN) 3 : 1

Theoretical and Computational Neuroscience

1.Peter Dayan and L. F. Abbott, Theoretical Neuroscience: Computational and Mathematical Modeling of Neural Systems, 2005. 2.Christof Koch and Idan Segev (Eds), Methods in Neuronal Modeling: From Ions to Networks, 1998. 3.Eric De Schutter (Ed.), Computational modeling methods for neuroscientists, 2009. 4.Eugene Izhikevich,Dynamical systems in neuroscience: the geometry of excitability and bursting, 2006. 5.Kenji Doya, Shin Ishii, Alexandre Pouget, Rajesh PN Rao (Eds), Bayesian Brain: Probabilistic Approaches to Neural Coding, 2007. 6.Fred Rieke, David Warland, Rob de Ruyter van Steveninck and William Bialek, Spikes: Exploring the Neural Code, 1999. 7.G. Bard Ermentrout and David H. Terman, Mathematical Foundations of Neuroscience, 2010. 8.Fabrizio Gabbiani and Steven James Cox, Mathematics for Neuroscientists, 2010. 9.Gilbert Strang, Introduction to Linear Algebra, Fourth Edition, 2009.

Rishikesh Narayanan

Pre-requistes : None

References : Need for and role of theory and computation in neuroscience, various scales of modelling, ion channel models, single neuron models, network and multi-scale models, models of neural plasticity. Oscillations in neural systems, central pattern generators, single neuron oscillators, network oscillators information representation, neural encoding and decoding, population codes,hierarchy and

MB 211 (AUG) 3 : 1

Advanced Methods in Molecular Simulations

Advanced Methods in Molecular Simulations

Anand Srivastava

Pre-requistes : None

References : None

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, ionchannels, 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-requistes : None

References : None

MB 303 (JAN) 3 : 0

Elements of Structural Biology

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

Balasubramanian Gopal

Pre-requistes : None

References : None

MB 305 (JAN) 3 : 0

Biomolecular NMR Spectroscopy

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

Siddhartha P Sarma , Ashok Sekhar

Pre-requistes : None

References : None

MB 222 (AUG) 3 : 0

Electron microscopy and 3D image processing for Life sciences

Objectives and basic working principles of different types of microscopes. Different types of electron microscopies and their applications. Basic introduction of electron microscopy physics and optics. Principles of image formation, Fourier analysis, Contrast Transfer Function and point spread function (electron scattering, phase contrast, electron–specimen interactions, electron diffraction). Characteristics of various advanced sample preparation, imaging, data collection techniques of bio-molecules for negative staining and cryo-electron microscopy. Basic principles and introduction to single particle cryo-EM structure determination, including Random Conical Tilt Pair, Orthogonal Tilt pair, 3D reconstruction using cryo-electron tomography and sub-tomogram averaging. Latest advancements in methodologies for application to biological systems.

Somnath Dutta , Vidya Mangala Prasad

Pre-requistes : Basic knowledge in matrix, probability theory, basic physics like optics, light, modern physics, wave nature of electrons,electron

References : Books and references 1. John J. Bozzola and Lonnie D. Russell (1992). Electron Microscopy (Jones & Bartlett Publishers). 2. Ray F. Egerton (2005). Physical Principles of Electron Microscopy: An Introduction to TEM, SEM, and AEM (Springer). 3. Elaine Evelyn Hunter and Malcolm Silver (1993). Practical Electron Microscopy: A Beginner's Illustrated Guide (Cambridge University). 4. Ludwig Reimer

MB 215 (JAN) 2 : 0

Neuronal Ion Transport in Health and Disease

Neuronal membrane properties, membrane ion channels and transporters, voltage and ligand-gated ion channels, store-operated channels, intracellular calcium signaling, designer channel receptors, optogenetics and chemogenetics, ion channel macromolecular complexes in neuronal transmission, genetic and acquired neuronal channelopathies, the plasticity of ion channels and transporters in neurological disorders: epilepsy, migraine, aging, dementia, amyotrophic lateral sclerosis (ALS) etc.

Giriraj Sahu

Pre-requistes :

References : 1. Ion Channels of Excitable Membranes: Bertil Hille 2. Neurobiology of Brain Disorders: M. Zigmond 3. Ion Channels and Disease: Frances M. Ashcroft 4. Ion Channels in Health and Disease: Geoffrey S. Pitt 5.The Neuron, Cell and Molecular Biology: Irwin B. Levitan and Leonard K. Kaczmarek.

MB 202 (AUG) 3 : 0

Introduction to Macromolecular X-ray Crystallography

Crystal morphology and 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'sLaw, Fourier transformation and structure factor, reciprocal lattice, experimental phasing methods . Basic ideas of structure determination, Patterson and Fourier methods, refinement procedures.

Aravind Penmatsa

Pre-requistes : None

References : Buerger M.J., Elementary Crystallography Woolfson M.M., An Introduction to X-ray Crystallography. Stout H. and Jenson L.H., X-ray Structure Determination, Macmillion, 1968. Macromolecular Crystallography- Benhard Rupp

MB 216 (JAN) 2 : 0

AI in Structural Biophysics and Molecular Therapeutics

Part 1 (first half of the semester): Fundamental computational tools and algorithms of ML/DL
Basics Mathematics for ML (Linear Algebra & Probability Theory)
Fundamentals of ML (Trading, regresdion analyses, Error/ loss/ objective function, Back propogation)
Molecular Representation and Representation Learning
Simple Neural Network, Multi layer perceptron , Convolution neural network (CNN), Recurrent neural network (RNN),
Knowledge graph representation learning: Graph Neural Network (GNN)
Latent space, dimensionality reduction, auto-encoders, and Unsupervised Machine Learning.
Generative Models for Science; Reinforcement Learning; Diffusion Models; Fundamentals of Transformers

Part 2 (second half of the semester)
Detailed study of important recent papers and DL tools related structural biophysics and drug discovery.
AlphaFold Series of tools; Rosetta Diffusion Model for protein design; BindCraft; Boltz; BioEMU, etc (see references)

Anand Srivastava

Pre-requistes :
Basics in Conformations of Biomolecules (MB206 or equivalent); Basic Mathematics
References : References (Books)
1. Deep Learning (Adaptive Computation and Machine Learning series) by Ian Goodfellow, Yoshua Bengio, and Aaron Courville

Developmental Biology and Genetics

Preface

RD 201 (AUG) 2 : 0

Genetics

Genetics: Mendelian genetics: Formulation of the laws of heredity, Genes and chromosomes, Morgan, the fruit fly, and classical genetics; Linkage: violation of independent assortment; Recombination frequency and map distances; Gene interactions. Population and evolutionary genetics: Allele frequencies in populations – genetic equilibrium, Factors affecting allele frequency; chromosomal aberration and human diseases, Extranuclear inheritance, Sex determination & Sex chromosome evolution, Gene mutation, DNA-repair and Transposition.

Epigenetics: Overview and concepts, Epigenetic modifications, Chromatin structure and function, Linking RNA to chromatin, Polycomb and Trithorax group proteins, Genome organization, Transcriptional bursting, Genomic imprinting, Dosage compensation; Epigenetics & human diseases, Epigenetics of Aging, Transgenerational epigenetic inheritance, climate change adaptation, Epigenomics.

Srimonta Gayen

Pre-requistes : None

References : References:

1. Concepts of Genetics by Klug, Cummings, Spencer, Palladino and Killian. 12th edition.

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 iGPCRs 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.

Nikhil R Gandasi

Pre-requistes : None

References : None

RD 212 (AUG) 0 : 1

Research Methods in experimental Biology

This course provides students with laboratory experience in basic molecular biology, fluorescence microscopy, electrophoresis, and blotting. The course also contains specific modules on data presentation, statistics and biosafety measures that the student will undertake. Additional content (10-20%) will be designed by the advisors based on the specific nature of work in individual laboratories. The student will be required to prepare a written report on the work done in the laboratory during the semester including appropriate statistics. The purpose of this course is to allow PhD students to gain expertise in research methodologies, experimental approaches, and analytical thinking common to various research laboratories in the MRDG department. Evaluation will be based on the report prepared by the student, and a presentation made to the faculty of the department at the end of the semester

Rajakumari Sonaimuthu , Shantanu P Shukla

Pre-requistes :

Admission into the PhD program in MRDG

References : To be decided by individual instructor (faculty of MRDG)

RD 213 (AUG) 2 : 0

Stem cells and Mammalian development

References:

1. Concepts of Genetics by Klug, Cummings, Spencer, Palladino and Killian. 12th edition.

2. Epigenetics by David Allis, Marie-Laure Caparros, Thomas Jenuwein and Danny Reinberg, 2nd edition.

Annapoorni Rangarajan , Srimonta Gayen

Pre-requistes : None

References : References:

1. Concepts of Genetics by Klug, Cummings, Spencer, Palladino and Killian. 12th edition.

Life Sciences

Preface

The MSc Life Sciences program is comprised of comprehensive foundational course work combined with a vast selection of electives, leading towards a specialisation in one of five fields of Biology. Students also have labs designed to introduce them to tools and techniques, as well a lecture series and workshops for broader skill development. In the final year, students engage in independent research projects that result in an MSc thesis.

LS 102 (AUG) 1 : 0

Opportunities and Extensions in Life Sciences - Pa

This course is deigned to expose students enrolled in the MSc in Life Sciences programme to opportunities and extensions in the field of biological sciences. The course will be conducted as a series of lectures and workshops by invited guests on topics, such as, IP/ patent laws; Humanities, including science history; Innovation and Entrepreneurship; Artificial intelligence and data analytics; Science Policy, governance and management; opportunities and pitfalls in BioMedical Research; Sci-Art in the alternative medium; Science communication and journalism; including Ethical use of animals & their care; Biosafety and practice.

The course will span two semesters and each month will be devoted to one of the eight numbered topics above. Invited guests will conduct 2-3 lectures / workshop a month (1 hour each) and students will have an assignment or a presentation to conduct for each of the topics that will involve independent research. For example, for the Science Communication session, students will interact with science journalists and will learn how to write a science news article. For the Innovation and Entrepreneurship session, students will meet a biomedical entrepreneur and will be asked to present a business model for a hypothetical biomedical product. Assignments will therefore range from written reports to presentations in class during the month devoted to the session.

Maria Thaker

Pre-requistes : None

References : will be provided

LS 103 (JAN) 1 : 0

Opportunities and Extensions in Life Sciences - Part 2

This course is deigned to expose students enrolled in the MSc in Life Sciences programme to opportunities and extensions in the field of biological sciences. The course will be conducted as a series of lectures and workshops by invited guests on topics, such as, IP/ patent laws; Humanities, including science history; Innovation and Entrepreneurship; Artificial intelligence and data analytics; Science Policy, governance and management; opportunities and pitfalls in BioMedical Research; Sci-Art in the alternative medium; Science communication and journalism; including Ethical use of animals & their care; Biosafety and practice.

The course will span two semesters and each month will be devoted to one of the eight numbered topics above. Invited guests will conduct 2-3 lectures / workshop a month (1 hour each) and students will have an assignment or a presentation to conduct for each of the topics that will involve independent research. For example, for the Science Communication session, students will interact with science journalists and will learn how to write a science news article. For the Innovation and Entrepreneurship session, students will meet a biomedical entrepreneur and will be asked to present a business model for a hypothetical biomedical product. Assignments will therefore range from written reports to presentations in class during the month devoted to the session.

Maria Thaker

Pre-requistes : None

References : will be provided

LS 209 (AUG) 0 : 2

Laboratory course in Molecular Techniques

bacterial culturing, vectors, DNA isolation, transformation, cloning, expression and purification of proteins; characterization by western blotting/ ELISA; cell culture, transfection, stable line generation, gene expression analysis by RT-PCR; fluorescence microscopy, immunofluorescence; viability assessment; Alamar blue / MTT assay; flow cytometry and cell sorting. Biophysical techniques - Concept of absorption and spectroscopy. Concept of protein/nucleic acid folding (CD and Fluorescence); Separation of protein and identification (Chromatography and Mass spectrometry); Bioinformatics.

Saravanan Palani , Meetali Singh

Pre-requistes : None

References : Wilson And Walker's Principles And Techniques Of Biochemistry And Molecular Biology

LS 208 (JAN) 2 : 0

Physiology and Neurobiology

Physiology: General concepts in histology, embryology and physiology. Cardiovascular physiology: Evolution of circulatory system, heart and vascular system and related diseases. Pulmonary Physiology: Evolution of respiratory mechanisms, lungs, and related diseases. Renal physiology: Evolution of renal system, kidneys, and related diseases. Gastrointestinal physiology: digestion, absorption, fluid balance kidney liver axis. Endocrinology: Hypothalamus, pituitary, thyroid gland, adrenal gland, pancreas. Functions and diseases. Neurobiology: A brief history of neuroscience and the neuronal doctrine; cell biology of a neuron; biochemical basis of resting membrane potential and action potential; neuronal connectivity, synaptic transmission and plasticity; sensory and motor systems; learning and memory; cognition; brain disorders.

Sandeep M Eswarappa , Ramray Bhat , Ashesh Kumar Dhawale

Pre-requistes : None

References : 1. Principles of Neural Science by Kandel et al (6th Edn) 2. Neuroscience: Exploring the Brain by Bear et al (4th Edn)

LS 205 (JAN) 3 : 0

Ecology and Evolution

This course will consist of lectures, readings and in-class discussion sessions led by students. It will have two modules, one for ecology (Sumanta Bagchi) and another for evolution (Praveen Karanth). It will have two 1.5-hr long sessions every week. In lectures, the instructor(s) will cover topics related to history of evolutionary thought, levels and types of selection, systematics, phylogenetics, ecology, biodiversity, ecological interactions, functioning of ecosystems and various threats faced by natural and human-modified ecosystems under global change. Through assigned readings, students will develop a broad understanding of how ecology and evolution provide a basis to understand life on earth. Student learning will be evaluated with a mid-term and an end-semester exam, each worth 50% of total marks. Course topics in Evolution: History of evolutionary theory; Why study evolution; Classification, Diversity of life; Phylogenetics; Levels of selection; Evolution of sex, why two sexes. Anisogamy and mating systems; Types of selection: Sexual selection, Kin selection, frequency depended selection, R vs. K selection; Evolutionary arms race, coevolution. Topics for Ecology: Earth as a biogeochemical system; Geographical variation in distribution of life on earth; Population dynamics and species interactions; Biodiversity: distribution, conservation, and restoration; Ecosystem functions and services; Global change: threats to biodiversity and their mitigation

Kartik Sunagar , Saskya Daly Van Nouhuys

Pre-requistes : None

References : • Begon, M. JL Harper, and CR. Townsend (2020) Ecology: from individuals to ecosystems. John Wiley & Sons, (or other available editions) • Evolutionary biology Douglas J. Futuyma (1998) 3rd ed. Sinauer Associates Inc, • Weekly assigned readings from instructors

LS 210 (JAN) 0 : 2

Laboratory course in Genetics and Ecology

Genetics - Basic genetics with Escherichia coli, Saccharomyces cerevisiae, Caenorhabditis elegans, Drosophila melanogaster, and Arabidopsis thaliana and overview of databases that can be used to understand mutants of each organism. Experiments to understand mating type determination using S. cerevisiae. Experiments to demonstrate different patterns of inheritance: genetic crosses and analysis of cross progeny using D. melanogaster and C. elegans. Studying visual phenotypes and behavioural phenotypes in D. melanogaster and C. elegans. Learning PCR based genotyping of C. elegans mutants. Observing mutants of A. thaliana.

Ecology - Key concepts in Ecology, Evolution and Behaviour through field observations, manipulative experiments, and computer simulations. Through field measurements: diversity and distributions of organisms, the concept of niche and trophic ecology. Through manipulative experiments with live animals: competition and sexual selection. Key concepts of material transfer and energy flow through ecosystems. Field measurements of net ecosystem exchange via primary productivity and respiration. Carbon sequestration in biomass and soils. The role of microbes in the Carbon cycle, and Nitrogen cycle. Laboratory experiments to estimate parameters that control rates of photosynthesis, respiration, N-fixation. Emphasis will be on study design and the connection of process to pattern.

Maria Thaker , Kavita Babu

Pre-requistes : None

References : all materials will be provided

LS 204 (AUG) 3 : 0

Biochemistry and Biophysics

Biophysics - Atoms, molecules, and chemical bonds. Covalent and non-covalent interactions (vdW, H-bond, electrostatic interaction, hydrophobic interaction, p-p, cat-p interaction); Composition of biomolecules (proteins, nucleic acids, carbohydrate, lipids) and their conformational features (Proteins: Rama plot, secondary structure, domains, folds. Nucleic acids: A, B, Z DNA, t-RNA, micro RNA); Folding and stability of proteins and nucleic acids; Principles of biophysical chemistry (concept of acid-base/pH, reaction kinetics and thermodynamics); Application of Spectroscopic techniques to study biomolecular interaction (UV-Vis spectroscopy, Fluorescence spectroscopy, Fluorescence anisotropy, Infrared spectroscopy, Raman spectroscopy, Circular Dichroism spectroscopy, Surface plasmon spectroscopy, and its application to study biomolecular interaction; Methods to study Proteins - Basic techniques like mass spectrometry, X- ray crystallography, NMR, and cryo-EM. Biochemistry - The chemical components of a cell, Structure and function of biological molecules, Protein Structure Function and Dynamics, Metabolic pathways and metabolism as integrated regulated systems, Cell membrane, cellular transport, Enzyme kinetics, complex cellular processes. Bioenergetics, glycolysis, oxidative phosphorylation, coupled reactions, biological energy transducers. Principles of catalysis, enzymes and enzyme kinetics. Metabolism of carbohydrates, lipids, amino acids nucleotides and vitamins.

Jayanta Chatterjee , Purusharth Rajyaguru

Pre-requistes : None

References : The Molecules of Life: Physical and Chemical Principles by John Kuriyan, Boyana Konforti, David Wemmer Biochemistry by Jeremy M. Berg, Lubert Stryer, John Tymoczko, Gregory Gatto Lehninger Principles of Biochemistry by David L. Nelson, Michael M. Cox

LS 206 (JAN) 3 : 0

Developmental Biology and Genetics

Developmental Biology: Basic concepts in developmental biology; evolution and development; body axis specification in invertebrates; early vertebrate, invertebrate and plant development; gastrulation and neurulation; organogenesis; cell type determination; creation of specific organs (organogenesis); molecular mechanisms underlying morphogenetic movements, differentiation, and interactions during development; fundamental differences between animal and plant development; embryogenesis in plant – classical and modern views; axis specification and pattern formation in angiosperm embryos; organization and homeostasis in the shoot and root meristems; patterning in vegetative and flower meristems; growth and tissue differentiation in plants; stem cells and regeneration; evolution of developmental mechanisms.

Genetics: Mendelian genetics: Formulation of the laws of heredity, Genes and chromosomes, Morgan, the fruit fly, and classical genetics; Linkage: violation of independent assortment; Recombination frequency and map distances; Gene interactions. Population and evolutionary genetics: Allele frequencies in populations – genetic equilibrium, Factors affecting allele frequency. Developmental Genetics: Genetic dissection of developmental pathways (Drosophila, mouse, C. elegans); Sex determination & Sex chromosomes, chromosome mutations: variation in number and arrangement, Extranuclear inheritance, Gene mutation, Stem cell & regeneration, nuclear transfer. Epigenetics: Overview and concepts, Genomic imprinting, Dosage compensation; X-chromosome inactivation, DNA methylation and histone modifications, Linking RNA to chromatin, Gene regulation by Polycomb and Trithorax group proteins, Genome organization, Transcriptional bursting and allelic expression, Single cell gene expression dynamics, Phase separation; Epigenetics & human diseases/Aging.

Plant development: Plant responses to light, introduction of different photoreceptors, molecular insights of light perception, signaling role of different light in plant development; molecular basis of plant hormone perception and their signaling role in development and physiology; meristem homeostasis, control of flowering; plant responses to pathogen infection, role of lipid in plant immunity; molecular plant nutrition, recent advances in plant abiotic stress response.

Srimonta Gayen , Kavita Babu , Debabrata Laha

Pre-requistes : None

References : • Genetics: From Genes to Genomes; Leland Hartwell, Michael Goldberg, Janice Fischer and Leroy Hood. ISBN-13: 9781259700903
• Epigenetics, Edited by C. David Allis, Marie-Laure Caparros, Thomas Jenuwein and Danny Reinberg. ISBN: 9781936113590
• Plant Physiology and Development, Sixth Edition; Lincoln Taiz, Eduardo Zeiger, Ian M. Møller, and Angus Murphy. ISBN: 9781605357454

LS 203 (AUG) 3 : 0

Microbiology, Virology and Immunology

Microbiology - Microbial taxonomy; Microbial diversity, evolution and genomics; Horizontal gene transfer, Microbes as model of development,and as bioreactors and sensors; bioremediation; structure-function of bacterial cell; Bacterial physiology and nutrition; Phages, Plasmids and Transposons; bacterial pathogenesis; Antibiotics: mode of action and mechanisms of resistance; Quorum sensing and biofilms; Host-pathogen interactions and immune surveillance; Diagnostics and vaccine development; Origin of cellular life; Host-associated and free-living microbes; Physiological heterogeneity in bacterial populations; Bacterial predation, and survival strategies. Virology – Introduction to viruses, life cycles of temperate and lytic bacteriophages; Fundamental concepts in virology, biology and pathogenesis of major viral pathogens; Introduction to applied virology. Immunology - Cells and organs of the Immune system, Innate Immunity & Inflammation, B cell Development, Structure-functio

Dipshikha Chakravortty , Samay Ravindra Pande

Pre-requistes : None

References : Stanier, R.V., Adelberg E.A and Ingraham J.L., GENERAL MICROBIOLOGY, Macmillan Press, Fourth edition Atlas R.M., MICROBIOLOGY: FUNDAMENTALS AND APPLICATIONS, Macmillan Press Second Edition Goldsby, R. A., Kindt T. J., Osborne B. A., Kuby J., IMMUNOLOGY, W. H. Freeman & Company, New York Travers, J., Shlomchik, W., IMMUNOBIOLOGY, Garland Science

LS 299 (AUG) 0 : 28

Dissertation project

Dissertation project

Utpal Nath

Pre-requistes : None

References : None

LS 207 (JAN) 3 : 0

Fundamentals of Molecular Biology

Genes and gene-enzyme relation; DNA and heredity; models of DNA structure; DNA structure and topology; Restriction modifications systems; flow of genetic information, Central Dogma of Molecular Biology, Elucidation of genetic code; Translation: Eukaryotic translation, modes of Translational control. The journey of Operons by Jacob and Monod a) Organization of Gene Regulatory Elements in Prokaryotes b) The players of gene regulation: Inducers, Repressors and Co-repressors; Multiple Mechanisms of gene regulations in bacteria; Introduction to Eukaryotic Gene Transcription; Enigma of Epigenetics and Gene regulations a) Orchestration of Gene regulation through Chromatin remodeling b) Learning the language of Histones c) Conversations between DNA, RNA and chromatin; Finding Treasures in the junk: Role of non-coding RNAs in Gene regulation; The Genome Timeline: Structural, Functional and Comparative Genomics

Tanweer Hussain , Rajakumari Sonaimuthu , Meetali Singh

Pre-requistes : None

References : 1. Watson JD, Baker TA, Bell SP, Gann A and Levine M, Molecular Biology of the Gene, Benjamin-Cummings Publishing Company, 7th edition, 2013
2. Alberts B, Johnson A, Lewis J, Raff M, Roberts K and Walter P, Molecular Biology of the Cell, Garland Science 6th Edition

Division of Chemical Sciences

Preface

The Division of Chemical Sciences comprises of the Department of Inorganic and Physical Chemistry (IPC), Materials Research Centre (MRC), Department of Organic Chemistry (OC) and Solid State and Structural Chemistry Unit (SSCU). Students with a basic/advanced degree in Chemistry, Physics, Biology, or many 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 contemporary areas of theoretical and experimental research, covering all aspects of modern Inorganic and Physical Chemistry. The programme of instruction consists of class lectures, laboratory work and student seminars.

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

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

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

Prof. G. Mugesh

Dean

Division of Chemical Sciences

CD 213 (AUG) 3 : 0

Organic Chemistry – Structure and Reactivity

Stereochemistry and conformational analysis. Methods of deducing organic reaction mechanisms, Hammond postulate,Curtin-Hammett principle, linear freeenergy 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,Vignesh Palani

Pre-requisites : None

References :

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

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, Manyelectron 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.

Abhishek Sirohiwal

Pre-requisites : None

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

CD 214 (AUG) 3 : 0

Basic Mathematics

Multivariable Calculus (6): Exact and inexact differentials, partial derivatives, multi-dimensional integrals, numerical integration; Vector Calculus (6): Gradient, divergence, and curl and their physical significance, Green's theorem and Stokes' theorem; Maxima/Minima (3): Maxima/minima of multivariable functions with constraints (Lagrange multipliers); Series of Functions (3): Taylor series and Maclaurin series; Linear Algebra (6): Matrices, matrix eigen value problems, vector spaces; Differential Equations (6): Differential equations of quantum chemistry and chemical kinetics, numerical solutions of differential equations; Transformations (4): Dirac delta function, orthonormal functions, Fourier series, Fourier transforms, Laplace transforms and Legendre transforms; Probability and Statistics (8): Conditional probability, discrete and continuous random variables, mean and variance, moments of probability distributions, covariance and correlations, law of large numbers, central limit theorem, normal distribution, Poisson distribution, error propagation, curve fitting, and confidence intervals.

Sheetal Kumar Jain

Pre-requisites : None

References : H. Margenau and G. Murphy, The Mathematics of Physics and Chemistry; M. L. Boas, Mathematical Methods in the Physical Sciences; G. B. Arfken, H. J. Weber and F. E. Harris, Mathematical Methods for Physicists

CD 215 (AUG) 0 : 4

Organic & Inorganic Chemistry Laboratory

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

Partha Sarathi Mukherjee,Abhishake Mondal,Sharvan Kumar

Pre-requisites : None

References : None

CD 221 (JAN) 3 : 0

Physical Chemistry II: Statistical Mechanics

Thermodynamics: Basic Ideas and postulates (2), equilibrium conditions (2), thermodynamic potentials and extremum conditions (2), maximum work theorem (1), stability conditions (2), phase transitions (2); Postulates of statistical mechanics (1): Phase space, ensembles, ergodic hypothesis; Ensembles (3): Canonical ensemble, grand canonical ensemble, Isothermal-Isobaric ensemble and Fluctuations; Fermi-Dirac and Bose-Einstein Statistics (2): Derivations in the grand-canonical ensemble and behaviour in the classical limit; Ideal Monatomic and Diatomic Gases (5): Translational, vibrational and rotational partition functions, rigid rotor-harmonic oscillator approximation, thermodynamic functions; Black Body Radiation (2): Stefan-Boltzmann law and Wien's-displacement law; Crystals (2): Einstein and Debye models; Electron Conduction in Metals (2): Contribution to heat capacity at low temperatures; Non-Ideal Gases (3): Virial equation of state, and Virial coefficients in the classical limit; Classical Liquids (6): Distribution functions, radial distribution function and relation to thermodynamic quantities, Ornstein-Zernike equation, PY and HNC closure; Debye-Hueckel Theory (3): Theory for ionic solutions; Ising Model (3): Solutions in one-dimension for different boundary conditions and mean field theory.

Sai G Ramesh

Pre-requisites : None

References : (1) E. Fermi, Thermodynamics; (2) H .B. Callen, Thermodynamics and Introduction to Thermostatistics; (3) D. A. McQuarrie, Statistical Mechanics; (4) D. Chandler, Introduction to Modern Statistical Mechanics; (5) B. Bagchi, Statistical Mechanics for Chemistry and Material Science

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.

Prabeer Barpanda

Pre-requisites : None

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.

Durga Prasada Rao Hari,Vignesh Palani

Pre-requisites : None

References : Warren S., Designing Organic Synthesis, 1978,Carruthers W. S.,Some Modern Methods of Organic Synthesis 3rd edition, Cambridge University Press, 1986., Carery, F. A. and Sundberg, R. J., Advanced organic chemistry, Part B, 2nd ed., Plenum, 1984,House, Modern Synthetic Reactions, 1972.,Fuhrhop J. and Penzilin G., Organic Synthesis - Concepts, Methods, Starting Materials, Verlog Chemie 1983.

CD 224 (JAN) 2 : 1

Computers in Chemistry

Basic Coding: Writing simple expressions, conditionals, loops, arrays, functions, file I/O, modular programming; Basic plotting, data fitting (linear, polynomial regression), Confidence intervals, Numerical Methods - Integration, Differentiation, Root finding, Minimization in 1D, ODEs, Basic Statistical Analysis with Probability Distributions (Gaussian, Uniform, Exponential), Basic use of electronic structure packages such as Gaussian.

Vivek Tiwari

Pre-requisites : None

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.

Satish Amrutrao Patil

Pre-requisites : None

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

Akkattu T Biju

Pre-requisites : None

References : None

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.

Soumen Ghosh

Pre-requisites : None

References : None

CD 212 (AUG) 3 : 0

Inorganic Chemistry – Main group and coordination chemistry

Unusual bonding in hyper- and low valent compounds. Multiple bonding in main group compounds. Chains, rings, and cage. Main group organometallics. Chemistry of Group 8 elements. Coordination chemistry: Spectral properties; Orgel diagrams; Tanabe- Sugano diagrams; Magnetic properties; inorganic reactions and mechanisms: hydrolysis reactions, substitution reactions trans-effect; isomerization reactions, redox reactions; metal-metal bonding and clusters; mixed valence systems.

Geetharani K,Abhishake Mondal

Pre-requisites : None

References : Shriver D.F, Atkins P.W. and Langford C.H., Inorganic Chemistry,Freeman, NY Cotton F.A. and Wilkinson G. Advanced Inorganic Chemistry, 6th edition, Wiley, 2007. Huheey J.E., Inorganic Chemistry, Principles of Structure and Reactivity, Pearson, 4th edition. 2006.

Inorganic and Physical Chemistry

Preface

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

Anoop Thomas

Pre-requistes : None

References : (1) I. N. Levine, Molecular Spectroscopy. (2) W. S. Struve, Fundamentals of molecular spectroscopy (3) P. F. Bernath, Spectra of atoms and molecules (2nd Ed.). (4) F. A. Cotton, Chemical Applications of Group Theory

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.

Debasis Das

Pre-requistes : None

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; reaction types; classes of organometallic compounds: Main-group, transition metal, lanthanide and actinide compounds. Isolobal analogies, metal-metal multiple bonding in organometallic compounds and metal clusters. Organometallic catalysis: hydrogenation, C-C coupling, C-S coupling, hydroboration and hydrosilylation, C-H activation

Balaji R Jagirdar

Pre-requistes : None

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,NZiegler-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 copolymersetc., and mechanisms for stereo-regulation.

Ramakrishnan S

Pre-requistes : None

References : (1) Flory P.J., Principles of Polymer Chemistry. (2) Odian G.,Principles of Polymerization. (3) Paul C Hiemenz and Timothy PLodge,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.

Chinmoy Ranjan

Pre-requistes : None

References : (1) A. J. Bard and L. R. Faulkner, Electrochemical methods:Principles and Applications (Wiley 1990). (2) R. Greef, R. Peat, L. M. Peter, D. Pletcher and J. Robinson, Instrumental Methods in Electrochemistry (Ellis Harwood Ltd., 1985). (3) E. Gileadi, Electrode Kinetics for Chemists, Chemical Engineers and Material Scientists(VCH 1993). (4) C.A. Vincent, Modern Batteries (Edward Arnold, UK

IP 328 (JAN) 3 : 0

Astrochemistry

1. Measuring the Universe: Spectroscopy, Doppler shift and lineshape, Hubble constant and the age of Universe (5 Lectures). 2. Big bang to first atom, hydrogen and helium nuclei (3 Lectures). 3. Heavier elements and stars, classes of stars, stellar chemistry, stellar spectra (4 lectures). 4. Interstellar chemistry: Molecules in Space, interstellar medium, chemistry in interstellar space, gas phase reactions, surface reactions (10 Lectures). 5. Meteorite and comet chemistry, meteorite classification, mineralogy, chemical composition of comets (4 Lectures). 6. Planetary Chemistry, formation of earth, radiative heating, planetary atmosphere, atmospheric photochemistry, extrasolar planets (6 Lectures). 7. Laboratory based astrochemistry: a) Experiments, spectroscopy, molecular beams, microwave spectroscopy, cavity enhanced spectroscopy, kinetics and dynamics, b) Theory, chemical modelling, kinetic and dynamical data (10 Lectures).

Arunan E

Pre-requistes :
Available to PhD students (1st year onwards), Int PhD students (2nd year onwards), UG students (4th year onwards).

References : 1. Claire Vallance, Astrochemistry: From big bang to the present day (World Scientific, 2017). 2. Andrew M. Shaw, Astrochemistry: From Astronomy to Astrobiology (Wiley, 2006). 3. Sun Kwok, Organic matter in the Universe (Wiley-VCH, 2012).

Materials Research Centre

Preface

MR 222 (JAN) 3 : 0

Chemistry of Materials

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

Prabeer Barpanda

Pre-requistes : None

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

MR 306 (AUG) 3 : 0

Electron Microscopy in Materials Characterization

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

Ravishankar Narayanan

Pre-requistes : None

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

MR 308 (JAN) 2 : 1

Computational Modeling of Materials

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

Abhishek Kumar Singh

Pre-requistes : None

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

MR 309 (JAN) 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.

Subinoy Rana

Pre-requistes : None

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.

MR 310 (AUG) 3 : 0

Light emitting materials and devices

Introduction to organic light-emitting diodes (OLEDs), PLEDs, Pervoskite-LEDs and their application, color science, basic working principles of light emitting devices, device fabrication and characterization, practical demonstration of device fabrication. Design, synthesis and characterization of hole injection/transporting, electron injection/transporting and host materials. Types of emitting materials: fluorescence, phosphorescence, TTA, TADF, singlet fission, perovskite, and carbon dots and their application in light emitting devices. Dendrimers and dendronized polymers for light emitting devices. Practical demonstration of device fabrication in the laboratory.

Rajamalli P

Pre-requistes : None

References : 1. OLED Fundamentals (Materials, Devices, and Processing of Organic Light-Emitting Diode) by Daniel J. Gaspar and Evgueni Polikarpo 2. Organic light- emitting diodes (OLEDs) by Alastair Buckley 3. Color Vision and Colorimetry Theory and Applications by Daniel Malacara 4. Dendrimers and Other Dendritic Polymers (by Jean M. J. Fréchet and Donald A. Tomalia)

MR 313 (JAN) 3 : 0

Topological Phenomena in Functional Materials and

Foundations of Topology- Continuous deformations, topological objects, Homotopy classes, winding number/ topological charge, Topological defects vs. solitons, Topological protection and phase transitions, Physical examples of topologically equivalent systems
Introduction to Ferric Materials- Ferro- and antiferro- magnetism, electricity, elasticity, Multiferroics and order parameter coupling.
Topological Defects in Ferric Systems- Domain walls: Ising, Bloch, Néel; flux closure; vortex; merons; skyrmions; Magnetic and polar skyrmions; Energetics: exchange, DMI, Landau theory, elastic and gradient energies
Experimental Probes for Topological Defects- Real-space techniques: MFM, PFM, STEM; Momentum space technique: Reciprocal-space mapping; Electrical measurements: Topological Hall effect.
Functional Properties of Topological Structures- Skyrmion motion, topological Hall effect; Negative capacitance, neuromorphic behavior, chirality effects; Conducting domain walls.
Device Concepts and Applications- Racetrack memories (domain wall/skyrmion-based); Ultra-low-power transistors (negative capacitance); Chirality-driven logic devices; topological transistors Neuromorphic and reservoir computing architectures

Sujit Das

Pre-requistes :
• Solid State Physics/chemistry (covering crystal structures, band theory, and ferroic order parameters)

References : Topological Structures in Ferroic Materials. Jan Seidal. Springer Series in Materials Science (SSMATERIALS, volume 228)

N.D. Mermin, Review of Modern Physics

Organic Chemistry

Preface

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

Pre-requistes : None

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

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

Pre-requistes : None

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

OC 302 (AUG) 3 : 0

Asymmetric Catalysis: From Fundamentals to Frontiers

Basics of asymmetric catalysis including energetics of reactions;Lewis acid &cLewis base catalysis; Kinetic, Dynamic Kinetic and Parallel Kinetic Resolution; Desymmetrization reactions; Mechanistic studies of asymmetric reactions:cnonlinear 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

Pre-requistes : None

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

Solid State and Structural Chemistry

Preface

The Solid State and Structural Chemistry Unit was founded in November 1976 by Bharat Ratna Professor C. N. R. Rao. SSCU has provided major thrust to diverse frontier areas at the intersection of Chemistry, Physics and Biology. Since its beginning, SSCU has fostered a culture of excellence, and it leads IISc in terms of research quality and productivity. The department's research is highly interdisciplinary, spanning frontier areas at the intersection of Chemistry, Physics and Materials Science.

The unit offers graduate level courses in Quantum Chemistry, Advanced Statistical Mechanics, Electrochemistry, Photovoltaics, Energy Research and Crystallography.

SS 201 (AUG) 3 : 0

Thermodynamics and Statistical Mechanics

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

Govardhan P Reddy

Pre-requistes : None

References : None

SS 202 (AUG) 3 : 0

Introductory Quantum Chemistry

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

Vivek Tiwari

Pre-requistes : None

References : None

SS 205 (AUG) 3 : 0

Symmetry and Structure in the Solid State

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

Sreedhara M B

Pre-requistes : None

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

SS 209 (AUG) 3 : 0

Electrochemical Systems

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

Naga Phani B Aetukuri

Pre-requistes : None

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

SS 304 (AUG) 3 : 0

Solar Energy: Advanced Materials and Devices

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

Satish Amrutrao Patil

Pre-requistes : None

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

Chemical Science

Preface

CY 215 (AUG) 0 : 3

Advanced Laboratory - 1

Separation of Plant Pigments- Introduction to Thin-layer Chromatography and Column Chromatography; Synthesis of Methyl Benzoate (acid catalysed esterification); Triphenylcarbinol from Phenyl Magnesium Bromide and Methyl Benzoate (Grignard Reaction); Diels-Alder Reaction between Cyclopentadiene and Maleic anhydride; Benzoylation of Amino acid (Schotten-Baumann Reaction); Synthesis of 1,2,3,4,6-penta-O-acetyl glucopyranose; Water mediated Wittig Reaction – synthesis of cinnamates; Benzoin to Benzil; Benzil to Benzilic acid Rearrangement; Clemmenson reduction: Nitrobenzene to N-phenyl hydroxyl amine; Darzen's glycidic ester condensation: Benzaldehyde, ethyl bromoacetate, KOH, benzyltriethylammonium chloride; Synthesis and characterization of acetyl ferrocene; Synthesis and characterization of H2TPP, Ni/Cu/Zn-TPP complexes; Synthesis and characterization of HKUST-1; Synthesis and characterization of the polyoxometalate complexes and grafting the Amino Group; Synthesis and Use of a Nic

Abhishake Mondal , Sharvan Kumar

Pre-requistes : None

References : (1) A collection of interesting general chemistry experiments, Elias AJ, Universities Press, 2008 (2) Macroscale and Microscale Organic Experiments, Williamson KL and Masters K, Brooks/Cole, 2nd Edition, 2016 (3) A Small Scale Approach to Organic Laboratory Techniques, 3rd Edition, Pavia DL, Lampman GM, Kriz GS and Engel RG, Brooks/Cole Pub Co, 3rd edition, 2010 (4) College

CY 226 (JAN) 0 : 3

Advanced Laboratory - II

pH-metry, Potentiometry, Iodometry, Preparation and testing the buffer action of Phosphate buffers, Determination critical micellar concentration (CMC), Conductometry, Determination of equivalent conductance of weak electrolyte at infinite dilution following Kohlrausch law, Determination of rate and activation energy of acid catalyzed Ethyl acetate hydrolysis reaction, Study of first -order kinetics of reaction between potassium persulphate and potassium iodide -determination of rate constants at two different temperatures and activation energy, Langmuir Adsorption, Fluorescence, UV-VIS Spectroscopy, Cyclic Voltammetry, X-Ray diffraction.

Satish Amrutrao Patil

Pre-requistes : None

References : (1) Vogel's Quantitative Chemical Analysis, Mendham J, Pearson Education, 2009

CY 310 (JAN) 0 : 10

Research Project

To be conducted in individual faculty laboratories in the Division of Chemical Sciences. The students will be allowed to undertake collaborative projects with faculty members from other divisions. The supervisors for research projects will be assigned at the end of second semester, allowing the students to start their interactions with individual research groups, design their projects and initiate research activities.

Veerabhadrarao Kaliginedi

Pre-requistes : None

References : NONE

CY 224 (JAN) 3 : 0

Chemistry of Biomolecules

This course will provide a survey of fundamental topics in chemical biology/biochemistry with an emphasis on concepts and tools from chemistry that are employed for biological discovery. The topics include, amino acid structure, properties, and chemistry; Peptides; Proteins; Classification of enzymes and details of a few important proteins/enzymes; Nucleic acid structure, properties, and chemistry; DNA and RNA; Genetic code; DNA sequencing; Polymerase chain reaction; Lipid structure, properties, and chemistry; Membranes; Carbohydrate structure, properties and chemistry; Glycoconjugates and their importance in biology; Enzyme catalysis, mechanism, and kinetics; Fatty acid biosynthesis and metabolism; Biochemical mechanism of protein synthesis; Glycolysis and Krebs cycle; Drugs, drug targets, mechanism of action; Drug toxicity and metabolism; Molecules with metal ions, hormones, secondary metabolites etc.

Mugesh G

Pre-requistes : None

References : 1. Jeremy Berg, John L. Tymoczko, Gregory J. Gatto Jr and Lubert Stryer Biochemistry, WH Freeman; 9th ed. 2019 edition 2. Donald Voet, Judith G. Voet Biochemistry, 4th Edition, Wiley, 2011 3. Michael B. Smith Biochemistry-An organic chemistry approach 4. Nelson, D. L.; Cox, M. M. Lehninger Principles of Biochemistry -International Edition, 7th Edition, 2017.

CY 225 (JAN) 3 : 0

Spectroscopic Methods for Structure Determination

Physical Principles of Spectroscopy, Operating Principles of Spectroscopic Instruments, Physical Methods of Structure Elucidation Structure elucidation of organic compounds using physical methods: Principles underlying the following techniques and their applications in organic chemistry will be discussed. Ultraviolet, Visible, Infrared, NMR (1H and 13C) Spectroscopy, and Mass Spectrometry. Elementary aspects of Electron paramagnetic resonance (EPR) spectroscopy, Mössbauer.

Erode N Prabhakaran , Sharvan Kumar

Pre-requistes : None

References : (1) Structure Determination of Organic compounds, 4th edition, Ernö Pretsch, Phillipe Bühlmann, Martin Badertscher, Springer, 2009. (2) EPR Spectroscopy: Applications in Chemistry and Biology, Malte Drescher, Gunnar Jeschke, Springer, 2012.

CY 303 (JAN) 3 : 0

Inorganic Chemistry-2: 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.

Thilagar P

Pre-requistes : None

References : 1. Elschenbroich, Ch. 2005 Organometallics, 3rd edition, Wiley-VCH, Weinheim 2. Gupta, B.D. and Elias, A. J. 2013 Basic Organometallic Chemistry: Concepts, Syntheses and Applications (Second edition)

Division of EECS

Preface

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

E0 Computer Science and Engineering

E1 Intelligent Systems and Automation

E2 Communication Systems

E3 Electronic Devices, Circuits and Technology

E4 Power and Energy Systems

E5 High Voltage and Insulation Engineering

E6 Power Electronics and Drives

E7 Photonic Devices, Circuits and Systems

E8 Electromagnetic, Microwaves and Antennas

E9 Signal Processing, Acoustics and Bioengineering

All the departments in the Division provide facilities for research leading to the PhD and the 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 are numbered EE 299, CN 299, CS 299, ES 299, Ai 299, SP 299, and MV 299, respectively. We wish all the students a lively and intellectually rewarding experience in the Division of EECS at the Indian Institute of Science.

Prof. Rajesh Sundaresan

Dean

Division of EECS

Computer Science and Automation

Preface

E0 238 (AUG) 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, agents, Artificial Intelligence Applications and Programming.

Pre-requistes : None

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 224 (AUG) 3 : 1

Computational Complexity Theory

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

Chandan Saha

Pre-requistes : None

References : None

E0 225 (AUG) 3 : 1

Design and Analysis of Algorithms

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

Siddharth Barman , Arindam Khan , Rahul Saladi

Pre-requistes : None

References : None

E0 227 (AUG) 3 : 1

Program Analysis and Verification

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

Deepak D'Souza , Raghavan K V

Pre-requistes : None

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

E0 230 (AUG) 3 : 1

Computational Methods of Optimization

Need for unconstrained methods in solving constrained problems. Necessaryconditions 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

Pre-requistes : None

References : Fletcher R., Practical Methods of Optimization, John Wiley, 2000.~

E0 232 (AUG) 3 : 1

Probability and statistics

Gugan Chandrashekhar Mallika Thoppe

Pre-requistes : None

References : None

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.

Arpita Patra

Pre-requistes :

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

E0 240 (AUG) 3 : 1

Modeling and Simulation

Sumit Kumar Mandal

Pre-requistes : None

References : None

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 , Arkaprava Basu

Pre-requistes : None

References : None

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

Pre-requistes : None

References : None

E0 249 (JAN) 3 : 1

Approximation Algorithms

Combinatorial algorithms: greedy algorithms, local search based algorithms;Linear programming based algorithms: randomized rounding, primal-dual schema based algorithms, iterated rounding; multicut, sparsest cut and metric embeddings; Semidefinite programming based algorithms; Hardness of approximation. References: "The Design of Approximation Algorithms" by David Shmoys and David Williamson"."Approximation Algorithms" by Vijay Vazirani.

Anand Louis

Pre-requistes : None

References : None

E0 251 (AUG) 3 : 1

Data Structures and Algorithms

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

Sathish Govindarajan

Pre-requistes : None

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

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 ofThreads, 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.

Arkaprava Basu

Pre-requistes : None

References : None

E0 255 (JAN) 3 : 1

Compiler Design

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

Uday Kumar Reddy B

Pre-requistes : None

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

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-requistes : None

References : None

E0 261 (AUG) 3 : 1

Database Management Systems

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

Jayant R Haritsa

Pre-requistes : None

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.

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

Pre-requistes : None

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, DeepLearning, MIT Press, 2017

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

Pre-requistes : None

References : Edward S. Angel and Dave Shreiner. Interactive Computer Graphics: A Top-Down Approach with Shader-Based OpenGL. Pearson, 2011. Dave Shreiner, Graham Sellers, John Kessenich, and Bill Licea-Kane. OpenGL Programming Guide: The Official Guide to Learning OpenGL. Addison-Wesley, 2013.Recent Literature.

E0 272 (JAN) 3 : 1

Formal Methods in Software Engineering

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

Deepak D'Souza , Raghavan K V

Pre-requistes : None

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

E0 312 (JAN) 3 : 1

Foundations of Secure Computation

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

Arpita Patra

Pre-requistes : None

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

E0 322 (JAN) 3 : 1

Topics in Algebra and Computation

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

Chandan Saha

Pre-requistes : None

References : None

E0 331 (JAN) 3 : 1

Optimization for Machine Learning

Gugan Chandrashekhar Mallika Thoppe

Pre-requistes : None

References : None

E0 334 (AUG) 3 : 1

Deep Learning for Natural Language Processing

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

Shirish Krishnaji Shevade

Pre-requistes : None

References :

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 , Chaya Ganesh

Pre-requistes : None

References : None

E0 358 (AUG) 3 : 1

Advanced Techniques in Compilation and Programming for Parallel Architectures

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

Uday Kumar Reddy B

Pre-requistes : None

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

E0 361 (JAN) 3 : 1

Topics in Database Systems

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

Jayant R Haritsa

Pre-requistes : None

References : None

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.

Siddharth Barman

Pre-requistes : None

References : None

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, functionapproximation techniques, approximate dynamic programming, partially observable Markov decision processes, Q-learning, temporal difference learning, actor-critic algorithms.

Shalabh Bhatnagar

Pre-requistes : None

References : 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.

E1 396 (AUG) 3 : 1

Topics in Stochastic Approximation Algorithms

Shalabh Bhatnagar

Pre-requistes : None

References : None

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 JohnsonLindenstrauss lemma, etc. b.Streamingalgorithms: 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 al

Anand Louis

Pre-requistes : None

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.

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,

Vijay Natarajan

Pre-requistes : None

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

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 thelast 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 di

Sathish Govindarajan , Rahul Saladi

Pre-requistes : None

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

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 SNAR

Chaya Ganesh

Pre-requistes : None

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

CS 299 (JAN) 0 : 21

M Tech Project CSA

M Tech Project

Gugan Chandrashekhar Mallika Thoppe , Chaya Ganesh

Pre-requistes : None

References : M Tech Project

E0 315 (JAN) 3 : 1

Measure Theoretic Probability

Syllabus:Sigma-Field, Construction of Probability Spaces and Measures, Random Variables and Measurability, Independence, Integration and Expectation, Monotone Convergence, Dominated Convergence, almost sure and in- probability convergence, Convergence in Distribution, Central Limit Theorem, Conditional Expectation and Martingales.

Ambedkar Dukkipati

Pre-requistes :
Linear Algebra and Probability (3:1) or equivalent cours

References : 1. G.R.Shorack, Probability for Statisticians, Springer, Second Edition, 2017 2. R.Ash and C. Doleans-Dade, Probability and Measure Theory, 1999

E0 360 (JAN) 3 : 1

Hypergraphs and Set systems

Turan Problem for Hypergraphs, Saturated Hypergraphs,Well-separated systems, Helly families, Hypergraphs with a given number of edges; Intersecting families, Factorizing complete hypergraphs, Weakly saturated hypergraphs, Sperner Systems,Littlewood-Offord problem, Shadows, Isoperimetric Problems.

Sunil Chandran L

Pre-requistes :

References : Bela Bollabas: Combinatorics: Set systems, Hypergraphs, Families of Vectors and Combinatorial Probability, Cambridge University Press, ISBN-13: 0521337038

E0 213 (JAN) 3 : 0

Quantum Safe Cryptography

Introduction to cryptography and communication security; Symmetric Key and Asymmetric Key Cryptosystems for data encryption and authentication; Impact of Quantum Computing on currently deployed cryptosystems; Some candidate post-quantum public key encryption and digital signature schemes using Error Correcting Codes, Lattices, Isogeny over Elliptic Curves, Multivariate-polynomials over finite fields, Cryptographic Hash Functions; Protocols for quantum-safe secure communication.

Sanjit Chatterjee

Pre-requistes :

References : (1) Bernstein D.J., Buchmann J. and Dahmen E. (Eds.): Post-Quantum Cryptography, Springer, 2010. (2) Galbraith S.D., Mathematics of Public Key Cryptography, Cambridge University Press, 2012. (3) Menezes A.J., van Oorshot P.C. and Vanstone S.A., Handbook of Applied Cryptography, CRC Press, 1996. (4)Recent research papers in the relevant areas.

E0 280 (JAN) 3 : 1

Deep Generative Models

Introduction to Probabilistic modelling in Machine Learning.
Generative models: Probabilistic PCA, Topic Models, Exponential Families,
Methods for Approximate Inference: Variational Methods, Markov Chain Monte Carlo Techniques
Deep Generative models: Variational Auto-Encoders, Generative Adversarial Networks, Deep Exponential Models, Variational Bayes.
Related Topics: Disentanglement, Representation learning.

Chiranjib Bhattacharyya

Pre-requistes :

This course will build on E0270, E1213.

References : Relevant Literature

E0 214 (AUG) 3 : 0

Applied Linear Algebra and Optimization

Linear Transformations and Linear Systems, Eigenvalues and Eigenvectors, Matrix Decompositions, Approximations and Completion with applications in Machine Learning and Recommender Systems. Optimization Basics- Gradient based methods, Coordinate descent methods, Newton Methods. Constrained optimization, Duality, and Applications in Machine Learning. Non-convex optimization for Machine Learning - Stochastic Optimization, Projected Gradient Descent and Alternating Optimization.

Shirish Krishnaji Shevade

Pre-requistes : None

References : i) Charu C Aggarwal, Linear Algebra and Optimization for Machine Learning, Springer, 2020 ii) Recent Literature

E0 294 (JAN) 3 : 1

Systems for Machine Learning

This course focuses on research and recent developments in hardware systems for machine learning algorithms. Computer systems currently focus on parallel-everything; chip multiprocessors, multithreading, GPUs, parallel software etc., These parallel everything hardware blocks also accidentally stumbled on the gold mine of machine learning algorithms. Machine learning (ML) algorithms at least until recently have relied extensively on matrix algebra, which can be highly parallelized. Hence, mapping these ML algorithms to GPUs, and massive CMPs has been an extremely fruitful exercise resulting in rapid growth in ML performance. While performance improvements still play a large role in ML systems, power and other constraints are equally important parameters. The need to maximize power efficiency has lead to a plethora of new ML accelerators, both in research and academia. At the same time a plethora of ML models have also started to appear with diverse computing needs, from recommender systems to Transformer based natural language processing models. The wide diversity of models and the heterogeneity of the hardware accelerators that run these models is one of the prime subjects of focus in this course. On the data front, ML systems use overwhelming amounts of training data that must be parsed, pre-processed and formatted to feed to the ML computing pipelines. Hence, there is a desire to enable data processing acceleration through near data processing. Novel memory and storage paradigms have been proposed to enable such near data processing. This second important focus of this course is to present a variety of near data processing techniques for ML pipelines. There is no hiding from security breaches in ML (and also in general computing).Security has become a key issue of concern for microarchitectures in the last decade. Data privacy and integrity is also important for ML systems to be trusted in critical application domains, such as medicine and transportation. We will cover privacy and security aspects of ML systems as the third module in this course

Sumit Kumar Mandal

Pre-requistes :

References : Sze, Chen, Yang and Emer: “Efficient Processing of DNNs,” Morgan&Claypool Press. 2021. ISBN: 9781681738321

Deep Learning for Computer Architects https://www.morganclaypool.com/doi/pdfplus/10.2200/S00783ED1V01Y201706 CAC041

E0 324 (JAN) 3 : 0

Advanced Topics in Optimization for Machine Learning

- Preliminaries: Lipschitz continuity, Smoothness - Gradient descent:convergence for smooth non-convex functions, smooth, convex and strongly-convex functions, Nesterov Acceleration, Heavy-Ball momentum and its convergence for quadratics - Convergence for Stochastic Gradient Descent: convergence for smooth (convex and non-convex) functions, Strongly convex functions,I nterpolation, Growth conditions - Variance reduction, SVRG, SAGA and its convergence - Second Order Methods - Subgradient Descent and its convergence for Lipschitz, convex functions - Online Convex Optimization : Online Gradient Descent, Follow the (regularized) leader and their regret bounds - AdaGrad : Regret bounds for convex, Lipschitz functions, Accelerated Adagrad, Other Variants - First order methods for Convex-concave - Optimization with Uncertainty: Optimization of Conditional Value at Risk

Anant Raj

Pre-requistes :
Basic Numerical Optimization Course (E0 230)

References : - Convex Optimization: Algorithms and Complexity, Bubeck, 2014 - First-order Methods in Optimization, Beck, 2017 - A ModernIntroduction to Online Learning, Orabona, 2019 - Research Papers

E0 319 (AUG) 3 : 0

Learning-Theoretic Foundations of Modern Machine L

- Decision Theory: Loss, risk, optimal predictors, Decomposition of excess risk
- Concentration inequalities: Hoeffding Inequality, Bernestein, Benett
- Ridge regression: Dimension independent bounds, operator based bound
- Estimation error: Finite number of hypotheses and covering numbers, Rademacher Complexity, VC dimension
- Consistent Estimators: Nadaraya-Watson estimators, K-nearest-neighbors, Universal consistency

- Kernels: Representer theorems. Algorithms. Analysis of well-specified models
- Sparsity Inducing Regularizers: L0 penalty. L1 penalty, Recovery Guarantee

- Single hidden layer neural networks: Estimation error, Approximation properties and universality

- Generalization bounds through stochastic gradient descent: Algortithmic Stability, Computational Regularization

- Learning single index models using SGD on neural networks

- Overparametrized models: Benign Overfitting, Tempered Overfitting, High Dimensional Limit

- Community Detection and the Power of Convex Relaxations
- Distribution property testing and estimation

Anant Raj

Pre-requistes :
E0 270, E0 232, UMC 203

References : 1. Learning Theory from First Principal : Francis Bach, 2024.
2. Learning theory lecture notes : Hayek and Raginsky (UIUC)
3. Foundation of Data Science : Avrim Blum, John Hopcroft, and Ravindran Kannan

Electrical Communication Engineering

Preface

M.Tech (Electronics & Communication) - Program Requirements

OVERALL STRUCTURE: The programme requires 36 credits of coursework and 28 credits of project work.

The coursework requirements in the program include three compulsory core courses and at least one course from each of the three broad groups of courses listed below.

Program Core (9 credits)
E2 202 Random Processes (3:0)
E2 211 Digital Communication (3:0)
E2 285 MTech ECE Laboratory Course (1:2)

Group A (Communication & Networks)
(at least 3 credits)
E2 201 Information Theory (3:0)
E2 203 Wireless Communication (3:0)
E2 204 Stochastic Processes and Queuing Theory (3:0)
E2 205 Error-Control Coding (3:0)
E2 221 Communication Networks (3:0)
E2 241 Wireless Networks (3:0)
E2 242 Multiuser Detection (3:0)
E2 251 Communication Systems Design (3:0)

Group B (Signal & Information Sciences)
(at least 3 credits)
E0 259 Data Analytics (3:1)
E1 244 Detection and Estimation Theory (3:0)
E1 245 Online Prediction and Learning (3:0)
E2 212 Matrix Theory (3:0)
E2 236 Foundations of Machine Learning (3:1)
E9 203 Compressed Sensing and Sparse Signal Processing (3:0)
E9 211 Adaptive Signal Processing (3:0)
E9 231 MIMO Signal Processing (3:0)
E9 241 Digital Image Processing (2:1)

Group C (High Frequency Circuits & Systems)
(at least 3 credits)
E3 220 Foundations of Nanoelectronic Devices (3:0)
E3 237 Integrated Circuits for Wireless Communication (3:0)
E3 277 Introduction to Integrated Circuit Design (2:1)
E7 211 Photonics Integrated Circuits (2:1)
E7 221 Fiber-Optic Communication (2:1)
E8 204 Antenna Theory and Practice (3:0)
E8 242 Radio Frequency Integrated Circuits and Systems (2:1)
E8 262 CAD for High-Speed Chip Package Systems (3:0)

Electives: balance to meet a minimum of 36 course credits

Project (MTech Electronics and Communication) EX 299 (0:28)

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

Arup Polley

Pre-requistes : None

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

E0 259 (JAN) 3 : 1

Data Analytics

This course will be taught jointly by Professors Ramesh Hariharan, Vikram Srinivasan, and Rajesh Sundaresan. This course will develop modern statistical tools and modelling techniques through hands-on data analysis in a variety of application domains. The course will illustrate the principles of hands-on data analytics through several case studies (8-9 such studies). On each topic, we will introduce a scientific question and discuss why it should be addressed. Next, we will present the available data, how it was collected, etc. We will then discuss models, provide analyses, and finally touch upon how to address the scientific question. Topics will be from astronomy, visual neuroscience, genomics, sports, community networks, epidemiology, and topic modelling.

Rajesh Sundaresan

Pre-requistes : Random Processes (E2 202) OR Probability and Statistics (E0 232) OR equivalent.

References : There is no text book for this course. Slides of lectures will be available on the course's learning management system on Moodle.

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.

Vaibhav Katewa

Pre-requistes : None

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

E2 201 (JAN) 3 : 0

Information Theory

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

Rajesh Sundaresan

Pre-requistes : None

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

E2 202 (AUG) 3 : 0

Random Processes

The axioms of probability theory, continuity of probability, independence and conditional probability. Random variables and their distribution, functions of a random variable, expectation. Jointly distributed random variables, conditional distribution and expectation, Gaussian random vectors. Convergence of sequences of random variables, Borel-Cantelli Lemma, laws of large numbers and central limit theorem for sequences of independent random variables, 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.

Rajesh Sundaresan , Anurag Kumar

Pre-requistes : None

References : A. Kumar, Discrete Event Stochastic Processes: Lecture Notes for an Engineering Curriculum. Online book.

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

Pre-requistes : None

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

E2 204 (JAN) 3 : 0

Stochastic Processes and Queueing Theory

Basic mathematical modeling is at the heart of engineering. In both electrical and computer engineering, many complex systems are modeled using stochastic processes. This course will introduce students to basic stochastic processes tools that can be utilized for performance analysis and stochastic modeling. Detailed study of processes encountered in various stochastic dynamic systems, such as branching, counting, urns, infections, and queues. Course content: Poisson process, Renewal theory, Markov chains, Reversibility, Queueing networks, Martingales, Random walk.

Parimal Parag

Pre-requistes : None

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

E2 205 (AUG) 3 : 0

Error-Control Coding

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

Navin Kashyap

Pre-requistes : None

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

E2 207 (AUG) 3 : 0

Concentration Inequalities

Chandra R Murthy , Aditya Gopalan

Pre-requistes : None

References : None

E2 208 (JAN) 3 : 0

Topics in Information Theory & Coding

Relevant journal articles.

Sundar Rajan B

Pre-requistes : None

References :
The topics to be covered in this edition of the course include polar codes, Reed-Muller codes, and quantum error-correcting codes.

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

Pre-requistes : None

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 , Sundeep Prabhakar Chepuri

Pre-requistes :

References : References: Carl D Meyer, Matrix Analysis and Applied Linear Algebra,SIAM Publication, 2000 Theodore Shifrin and Malcolm Ritchie Adams,Linear Algebra: A Geometric Approach, W H Freeman and Comapany, Second Edition, 2011,Gilbert Strang, Linear Algebra and its Applications,Fourth Edition, Thomson Brooks/Cole, 2007. Horn, and Johnson, Matrix Analysis, Second Edition, Cambridge

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.

Parimal Parag

Pre-requistes : None

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

E2 251 (AUG) 3 : 0

Communications Systems Design

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

Chockalingam A

Pre-requistes : None

References : Tony J. Rouphael. Wireless Receiver Architectures and Design:,Antenna, RF,Synthesizers, Mixed Signal and Digital Signal Processing. Academic Press,2014~Lydi Smaini. RF Analog Impairments Modeling for Communication Systems Simulation: Application to OFDM-based Transceivers. John-Wiley & Sons, 2012.~Abbas Mohammadi and Fadhel M. Ghannouchi. RF Transceiver Design for MIMO

E2 331 (AUG) 3 : 0

Advanced Topics in Coding Theory

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

Sundar Rajan B

Pre-requistes : None

References : None

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

Pre-requistes : None

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

E7 211 (AUG) 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

Pre-requistes : None

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

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

Pre-requistes : None

References : A. Selvarajan, S. Kar and T. Srinivas, Optical Fiber Communications, Principles and Systems, Tata – McGraw Hill

E8 311 (AUG) 2 : 1

Advanced Topics in Electromagnetics

Vinoy K J

Pre-requistes : None

References : None

E9 203 (JAN) 3 : 0

Compressed Sensing and Sparse Signal Processing

Introduction to Compressed Sensing. Basic theory: l1 minimization, 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

Pre-requistes : None

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.

E2 236 (JAN) 3 : 1

Foundations of Machine Learning

Sundeep Prabhakar Chepuri

Pre-requistes : None

References : Foundations of Machine Learning, Mehryar Mohri, Afshin Rostamizadeh, and Ameet Talwalkar~Understanding Machine Learning, Shai Shalev-Shwartz and Shai Ben- David

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

Pre-requistes : None

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

MV 299 (JAN) 0 : 28

M.Tech Micro & VLSI Dissertation Project

MTech Microelectronics and VLSI Design Dissertation Project

Arup Polley

Pre-requistes : None

References : None

E8 204 (JAN) 3 : 0

Antenna Theory and Practice

The objectives of this course are to provide student researchers with: (a) fundamental knowledge regarding functioning of antennas, and (b)application-oriented design concepts for antenna systems. The coursewill have programming and design assignments using MATLAB Antenna Toolbox for understanding and visualization. Tentative Syllabus is as follows: 1. Definitions & Preliminary topics: Maxwell's Equations and Boundary conditions, Wave Equations,Infinitesimal (Hertzian)Dipoles. 2. Wire Antennas: Finite Length Dipoles from Transmission line approach, Monopoles, Inverted-F Antennas, Loop Antennas, Yagi-Uda and Log-periodic antennas. 3. Antenna Array Theory: Array factors, Linear and planar arrays, Array synthesis approaches, Microstrip patch and printed dipole arrays, Generalized Array factors using Cross-correlation Greens functions. 4. Aperture-type Antennas: Radiation from apertures, aperture distribution, horn and parabolic dish antennas. 5. Microstrip and Dielectric Antenna

Debdeep Sarkar

Pre-requisites :
Presence of preliminary knowledge about vectors, coordinate transform, partial differential equations, circuit theory and transmission lines

References : I. D. K. Cheng, Field and Wave Electromagnetics, Pearson Education Asia Ltd, Second Edition, 2006. II. C. A. Balanis, Antenna Theory - Analysis and design, John wiley, Fourth Edition, 2016. III. W. L.Stutzman and G. A. Thiele, Antenna Theory and Design, John Wiley & Sons Inc, 1981. IV. J.D. Karus, Antennas, McGraw Hill, 1988. V. I.J. Bahl and P. Bhartia, Microstrip antennas, Artech house,

E8 304 (AUG) 3 : 0

Electromagnetic Metamaterials: Concepts and Applications

• Background: General Historical perspective and idea of Metamaterials (MTMs), Dispersive model for the dielectric permittivity, Phase velocity and group velocity, Metamaterials and homogenization procedure, Metals and plasmons at optical frequencies, Wire mesh structures as low frequency plasmas, Diamagnetism in a stack of metallic cylinders, Split-ring resonator media, Media with negative permittivity and permeability: theory and properties, Origins of negative refraction and other properties. • Spatial Metamaterials: Transmission Line Realization (Brillouin's work), Ideal Homogeneous CRLH TLs (Composite Right-Left Handed Transmission Lines), LC Network Implementation and distributed 1D CRLH Structures,Conversion from Transmission Line to constitutive Parameters, Eigenvalue Problem for 2D MTMs. • Applications of Metamaterials: A.Microwave: Dual-band and enhanced band guided wave components,Negative and Zeroth-Order Resonators, Backfire-to-Endfire (BE)Leaky-Wave (LW) Antennas

Debdeep Sarkar

Pre-requisites :

References : 1. D. K. Cheng, Field and Wave Electromagnetics, Pearson Education Asia Ltd, Second Edition, 2006. 2. S. A. Ramakrishna and T.M.Grzegorczyk, Physics and Applications of Negative Refractive Index Materials, CRC Press, Taylor & Francis Group and SPIE Press,2009. 3. G. V. Eleftheriades and K. G. Balmain, Negative Refraction Metamaterials: Fundamental Principles and Applications

E3 277 (AUG) 2 : 1

Introduction to Integrated Circuit (IC) Design

1. Devices: Review of Device Characteristics, DC and Small Signal MOS I/V Characteristics, Short-channel effects and device models used in IC design, CMOS Processing and Layout. 2. Analog Circuits: CMOS CS/CG/CD Amplifiers, Cascodes, Current Mirrors, Differential Pairs. 3.Digital Circuits: MOS inverters: Static and Switching Characteristics, Combinational and Sequential MOS Logic Circuits, Low power CMOS logic circuits. 4.Important Design Concepts: Frequency Response, Noise, Feedback, Nonlinearity. 5.Larger Circuits and Sub-systems: Basic operational amplifier design, Stability and Compensation, OTAs. This course will provide hands-on exposure to industry standard VLSI design tools

Gaurab Banerjee

Pre-requistes :

References : 1. CMOS Digital Integrated Circuits, Analysis and Design, Kan,Leblebici, Kim, McGraw Hill Education, 4th edition. 2. Analysisand Design of Analog Integrated Circuits, Gray, Hurst, Lewis, Meyer, Wiley, 5th edition. 3. Design of Analog CMOS Integrated Circuits, Razavi, McGraw Hill Education, 2nd edition.

E2 285 (JAN) 1 : 2

MTech ECE Laboratory Course

Software and hardware experiments on commercial software packages and hardware platforms in digital communications, antennas, networks, signal processing, visible light communications, advanced numerical programming, and machine learning.

Sudhan Majhi

Pre-requistes :

References : None

EX 299 (JAN) 0 : 28

Project (MTech, Electronics and Communication)

This is the 28-credit MTech project mandatory for all MTech (Electronics and Communication) students, starting from the 2021-23 batch.

Navin Kashyap

Pre-requistes : None

References : Not applicable

E2 210 (JAN) 3 : 0

Quantum Error-Correcting Codes

This course is intended to serve as an entry into the field of quantum error-correction. The theory is developed from the basics, assuming the postulates of quantum mechanics. No background in quantum mechanics or quantum information processing will be assumed.
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Syllabus: Basics of quantum computation: qubits, quantum states, quantum gates, measurement, density matrices, trace, partial trace; the no-cloning theorem
Quantum noise models: bit flips and phase flips, depolarizing channel, amplitude damping, phase damping
Quantum error-correction: quantum codes; the Knill-Laflamme conditions; Pauli error basis; discretization of quantum errors
Constructions: Shor's code, CSS codes, stabilizer codes, topological codes (surface codes, color codes), quantum LDPC codes; encoding/decoding circuits
Bounds: quantum Hamming bound, quantum Singleton bound, quantum Gilbert-Varshamov bound
Entanglement-assisted quantum error-correcting codes;
Fault-tolerant quantum computation

Vijay Kumar P

Pre-requistes : E2 205 (Error-Control Coding) or equivalent, or permission of instructor

References : M.A. Nielsen and I.L. Chuang, Quantum Computation and Quantum Information, Cambridge University Press, 2010 (10th Anniversary Edition)

E2 217 (AUG) 3 : 1

Machine Learning for Wireless Communication

Introduction to Machine Learning: Overview of supervised semi-supervised and unsupervised. Wireless Communications: AI/ML-based source coding and channel coding, PAPR reduction for the OTFS and OFDM modulation scheme, Autoencoder, Classification of wireless signals, Modulation classification, and deep unfolding methods. Signal Estimation and Detection: AL/ML based Parameter estimation, STO and CFO estimation, Channel estimation, MIMO/OFDM/OTFS detectors. Interference: Interference classification and mitigation for wireless communication, Self interference cancellation for in-band full duplex radios. Spectrum sharing and resource allocation: Resource allocation, Spectrum sharing, Power allocation using reinforcement learning (RL) and deep RL

Sudhan Majhi

Pre-requistes :
Basics of Machine Learning and python

References : 1. I. Goodfellow, Y. Bengio, and A. Courville, Deep Learning, MIT Press, 2016. 2. R.-S. He and Z.-G. Ding, Applications of Machine Learning in Wireless Communications, IET, 2019. 3. F.-L. Luo, Machine Learning for Future Wireless Communications, Wiley-IEEE Press,2020. 4. Y. C. Eldar, A. Goldsmith, D. Gündüz, and H. V. Poor, Machine Learning and Wireless Communications, Cambridge

E7 223 (JAN) 3 : 0

Fourier Optics

Analysis of two-dimensional signals and systems: Fourier analysis in two dimensions; Spatial frequency, space-frequency localization; Linear systems; Two-Dimensional Sampling theory; The Discrete Fourier Transform; Projectile-Slice Theorem; Phase retrieval from Fourier magnitude Foundations of Scalar Diffraction Theory: Historical introduction; From vector to Scalar Theory; Kirchhoff Diffraction formula; Rayleigh-Sommerfeld Diffraction formula; Generalization to Non-Monochromatic waves; Diffraction at boundaries; The angular spectrum of plane waves Fresnel and Fraunhofer Diffraction: Huygens-Fresnel Principle in rectangular coordinates; Fresnel Approximation; Fraunhofer Approximation; Examples of Fresnel and Fraunhofer Diffraction patterns; Beam Optics. Wave-Optics Analysis of Coherent Optical systems: A Thin Lens as a Phase Transformation; Fourier Transforming Properties of Lenses; Image Formation: Monochromatic Illumination; Analysis of Complex Coherent optical systems. Frequency Analysis of Optical Imaging Systems: Generalized Treatment of Imaging Systems; Frequency Response for Diffraction-Limited Coherent Imaging; Frequency Response for Diffraction-Limited Incoherent Imaging; Aberrations and Their Effects on Frequency Response; Comparison of Coherent and Incoherent Imaging; Confocal Microscopy Point-Spread Function and Transfer Function Engineering: Cubic Phase Mask for Increased Depth of Field; Rotating Point-Spread Functions for Depth Resolution; Point-Spread Function Engineering for Exoplanet Discovery; Resolution beyond the Classical Diffraction Limit; Light Field Photography. Wavefront Modulation: Wavefront Modulation with Photographic Film; Wavefront Modulation with Diffractive Optical Elements; Liquid Crystal Spatial Light Modulators; Deformable Mirror Spatial Light Modulators; Acousto-Optic Spatial Light Modulators; Other Methods of Wavefront Modulation. Analog Optical Information Processing: Coherent Optical Information Processing Systems; The VanderLugt Filter; The Joint Transform C orrelator; Application to Character Recognition; Image Restoration; Acousto-Optic Signal Processing Systems; Discrete Analog Optical Processors Holography: The Wavefront Reconstruction Problem; The Gabor Hologram; The Leith-Upatnieks Hologram; Image Locations and Magnification; Some Different Types of Holograms; Thick Holograms; Recording Materials; Computer-Generated Holograms; Degradations of Holographic Images; Digital Holography; Holography with Spatially Incoherent Light; Applications of Holography. Fourier Optics in Optical Communications: Fiber Bragg Gratings; Ultrashort Pulse Shaping and Processing; Spectral Holography; Arrayed Waveguide Gratings

Balaswamy Velpula

Pre-requistes :

References : Fourier Optics: Joseph Goodman Latest Edition

E2 237 (AUG) 3 : 0

Statistical Learning Theory

The course provides statistical guarantees on the performance of various machine learning algorithms such as classification and regression. The upper bounds are derived from Radmacher complexity and VC dimensions and the lower bounds are derived from the information theoretic methods. We also derive high dimensional asymptotics relating decision theory to statistical physics methods. Course contents: 1.Bias complexity trade off, Rademacher complexity, VC-dimension 2.Multiclass classification, decision trees, nearest neighbours 3.Parameter estimation and nonparametric regression 4.Stochastic gradient descent 5.Statistical decision theory 6.Large-sample asymptotics 7.Mutual information method and lower bound via hypothesis testing 8.Entropic bounds for statistical estimation 9.Strong data processing inequalit

Parimal Parag

Pre-requistes :
First graduate course in probability theory or equivalent, and instructor's approval.

References : 1. Yury Polyanskiy and Yihong Wu, "Information Theory: From Coding to Learning", Cambridge University Press, forthcoming. 2.Yihong Wu, "Information-theoretic Methods for High-dimensional Statistics", lecture notes. http://www.stat.yale.edu/~yw562/teaching/it-stats.pdf 3.Martin Wainwright, "High-Dimensional Statistics", Cambridge University Press, 2019. 4.Mehryar Mohri, Afshin

E9 247 (AUG) 3 : 1

Learning for 3D Vision and Inverse Graphics

Camera geometry, structure from motion, image based rendering for novel view synthesis, neural radiance fields (NeRFs), plenoxels and other grid based methods, 3D Gaussian splatting, sparse input novel view synthesis, deep depth priors, plane sweep volume, dynamic radiance fields, optical flow and motion priors, generalizable radiance fields, camera pose optimization.

Rajiv Soundararajan

Pre-requistes :
Deep learning and either image processing or computer vision

References : 1. David A. Forsyth and Jean Ponce, Computer Vision: A Modern Approach, Pearson Education, 2003, 2. Richard Szeliski, Computer Vision: Algorithms and Applications, Springer, 2010, 3. Recent papers

AI 299A (JAN) 0 : 25

Dissertation Project

Dissertation Project

Chetan Singh Thakur

Pre-requistes : None

References : As suggested by project advisor

E1 240 (AUG) 3 : 0

Theory of Multi-Armed Bandits

This course introduces the theory and algorithms underlying the multi-armed bandit (MAB) problem in various settings, along with the fundamental limits of the framework (lower bounds). The first part focuses on regret minimization in stochastic MABs, covering algorithms such as UCB, KL-UCB, IMED, and Thompson Sampling, and their regret analysis, modern design principles like Information-Directed Sampling and the Decision Estimation Coefficient, and lower bound techniques using both classical change-of-measure arguments and modern information-theoretic tools. We will also study non-stationary MABs (e.g., sliding window methods and piecewise-stationary models) and rotting/blocking bandits with monotonic reward structures.

The second part of the course focuses on sequential active hypothesis testing, which includes the best-arm identification (BAI) setting of MAB as a special case. Topics include Wald's power-one sequential testing framework, along with modern lower bounds and sample complexity analysis for optimal algorithms in point-vs-point, composite-vs-point, and composite-vs-composite settings. We will then cover the classical BAI problem under fixed-confidence and fixed-budget settings, including state-of-the-art lower bounds, impossibility results, and algorithms such as LUCB, Track-and-Stop, and Bayesian approaches like top-two sampling and its connection to Thompson Sampling. We will cover connections between BAI and Wald's testing framework, the gamification approach to BAI, and BAI with multiple correct answers, and epsilon-BAI. We will also explore linear bandits and optimal experimental design principles, including algorithms such as LinUCB, GLMs, epoch-greedy, and logistic models, along with A-, D-, and G-optimality criteria.

In the final part of the course, we will study generalizations such as dueling bandits (e.g., Relative UCB), stochastic partial monitoring (an application of the Information-Directed Sampling principle), and restless bandits (a generalization of MABs with time-evolving arms, where index-based policies such as the Whittle and Gittins indices are employed).

Shubhada Agrawal

Pre-requistes :
1. A course on probability theory or random processes.
2. Familiarity

References :
1. Introduction to Multi-Armed Bandits by Aleksandrs Slivkins
2. Bandit Algorithms by Tor Lattimore and Csaba Szepesvári
3. Multi-Armed Bandit Allocation Indices by John C. Gittins, Kevin D. Glazebrook, and Richard Weber

E1 341 (JAN) 3 : 0

Probabilistic Foundations for Sequential Learning

This course develops a rigorous probabilistic foundation for sequential and adaptive learning. We will begin with core ideas in martingale theory, including filtrations, conditional expectations, stopping times, Doob decomposition, optional stopping, maximal inequalities, convergence theorems, uniform integrability, and quadratic variation, as well as notions of convergence of probability measures. Building on these foundations, we study applications to time-uniform inference, covering Ville's inequality, mixture martingales, confidence sequences, and modern time-uniform concentration inequalities. The final part of the course will introduce large deviations theory, including Cramer and Chernoff bounds, rate functions, tilted distributions, the Gartner-Ellis theorem, and Sanov-type principles.

Shubhada Agrawal

Pre-requistes :
Random Processes (E2 202) and Analysis-1 (MA 221), or equivalent background.

References :
1. Probability with Martingales by David Williams
2. Self-normalized Processes, by de la Pena, Lai and Shao
3. Large Deviations Techniques and Applications, by Dembo and Zeitouni

Electrical Engineering

Preface

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 andfunction learning, multilayer feed forward networks, backpropagation, RBF networks, deep neural Networks, support vector machines, kernel based methods,feature selection and dimensionality reduction methods.

Prathosh A P

Pre-requistes : None

References : None

E1 251 (AUG) 3 : 0

Linear and Nonlinear Optimization

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

Muthuvel Arigovindan

Pre-requistes : None

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

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

Pre-requistes : None

References : References:,Proakis and Manolakis, Digital Signal Processing, Prentice HallIndia,.,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 213 (AUG) 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

Chandra Sekhar Seelamantula

Pre-requistes : None

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 261 (JAN) 3 : 1

Speech Information Processing

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

Prasanta Kumar Ghosh

Pre-requistes : None

References : Handbook of Speech Processing, Benesty, Jacob; Sondhi, M. M.; Huang, Yiteng (Eds.), Springer, 2008. Gold B, and Morgan N, Speech and Audio Signal Processing, John Wiley, 2000.,Douglas O'shoughnessy, Speech Communication,IEEE Press 2000. Taylor P, Text-to-Speech Synthesis, Cambridge Univ. Press,2009. Rabiner L R, and Schafer R W, Theory and applications of digital speech

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

Pre-requistes : None

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 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

Pre-requistes : None

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

Kiran Kumari

Pre-requistes : None

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 242 (JAN) 3 : 0

Nonlinear systems and control

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

Pavankumar Tallapragada

Pre-requistes : None

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

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 imeimplementation,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

Pre-requistes : None

References : Brown s, and Vranesic Z, Fundamentals of Digital logic with Verilog design,Tata McGraw Hill. Mazidi, Mckinlay and Causey, PIC Micro- controllers and Embedded Systems, Pearson. Franklin G F, Powell J D and Naeini, Feedback Control of Dynamic Systems, Pearson. Erickson R W and Maksimovic D,Fundamentals of Power Electronics, Springer. Proakis J G and Manolakis D K,Digital Signal

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-lowfrequency oscillations – methods of analysis for single and multi-machine systems, power system stabilizers.

Gurunath Gurrala

Pre-requistes : None

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

E4 233 (JAN) 3 : 0

Computer Control of Power Systems

Gurunath Gurrala

Pre-requistes : None

References : None

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

Pre-requistes : None

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

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 , Soham Chakraborty

Pre-requistes : None

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

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.

B S Rajanikanth

Pre-requistes : None

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

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 conditionmonitoring of transformers, natural frequencies and its measurement,moderntechniques. Introduction to HV switching devices,electric arcs, short circuit currents, TRV, CB types, air,oil and SF6 CB, short circuit testing.

L Satish

Pre-requistes : None

References : References: Bernard Hochart, Power Transformer Handbook,Butterworth, 1987.,The J & P Transformer Book,12th Edn, MJ 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

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 andcharacteristics 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.

L Satish

Pre-requistes : None

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

Pre-requistes : None

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.

E6 201 (AUG) 3 : 1

Power Electronics

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

Vishnu Mahadeva Iyer

Pre-requistes : None

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

E6 211 (JAN) 3 : 0

Electric Drives

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

Samir Hazra

Pre-requistes : None

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

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 , Tapas Roy

Pre-requistes : None

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 (AUG) 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

Pre-requistes : None

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 (AUG) 3 : 0

Advanced Power Electronics

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

Kaushik Basu

Pre-requistes : None

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

E6 226 (JAN) 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

Pre-requistes : None

References : None

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

Pre-requistes : None

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 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

Pre-requistes : None

References : None

E9 246 (JAN) 3 : 1

Advanced Image Processing

Image Features - Scale Invariant Feature Transform (SIFT), Speeded Up Robust Features (SURF), Generalized Hough Transform, Texture features, Evaluation Deep Learning of image features - Convolution layers, fully connected layers, back propagation, non-linear activation, batch normalization, network architectures Image Segmentation - Graph-based techniques, Active Shape Models, Active Appearance Models, deep learning based segmentation Image Restoration - Image denoising using statistical priors, order statistics based filters, deep learning methods, deblurring and sharpening, defogging, low light image enhancement Image Compression - Entropy coding, lossless JPEG, quantization, DCT, JPEG Object detection – RCNN and its improved variants like Fast-RCNN, Faster RCNN, SSD Instance Segmentation - Mask-RCNN Image Quality - Natural scene statistics, quality assessment based on structural and statistical approaches, blind quality assessment Generative Models- Generative adversarial networks, variational auto encoders, style transfer, cycle GAN, diffusion models. Vision Transformers

Soma Biswas , Rajiv Soundararajan

Pre-requistes : None

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.

SP 299 (JAN) 0 : 28

Dissertation Project

Sundeep Prabhakar Chepuri

Pre-requistes : None

References : None

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

Pre-requistes : None

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

EE 299 (JAN) 0 : 24

Project

MTech EE Project

Muthuvel Arigovindan

Pre-requistes : None

References : None

E0 350 (JAN) 3 : 1

Advanced Convex Optimization

Along with smooth convex analysis, a large part of the course will focus on nonsmooth convex analysis and particularly on subdifferential calculus. A novelty of the course would be to understand the connection between monotone operator theory and convex optimization, and how this can be used to analyze many commonly used iterative algorithms for smooth and nonsmooth optimization. There will be a project component wherein the students would be asked to apply these tools to various engineering problems. Syllabus: convex sets and functions, characterizations of convexity, topological properties, separation theorems, nonsmooth optimization (optimality conditions, constrained optimization, KKT condition), subdifferential calculus (existence, relation to gradient, sum rule, composition rule), proximal operator and Moreau's theorem, first-order algorithms for smooth optimization (gradient descent, projected gradient descent, proximal gradient method, stochastic gradient descent), monoton

Kunal Narayan Chaudhury

Pre-requistes :
Linear algebra, differential, and multivariate calculus. Some familiarity with real analysis will help but is not mandatory.

References : 1. L. Berkovitz, Convexity and Optimization in Rn, John Wiley & Sons, 2003. 2. T. Rockafellar, Convex Analysis, Princeton University Press, 2015. 3. Y. Nesterov, Lectures on Convex Optimization, Springer, 2018. 4. E. Ryu and S. Boyd, Primer on Monotone Operator Methods, Appl. Computational Math 15.1: 3-43, 2016. 5. H. Bauschke and P. Combettes, Convex Analysis and Monotone

E6 227 (JAN) 3 : 0

Power Electronics Design

Gate driver design : hard switching and soft switching characteristics of Si-based and wide-bandgap power semiconductors, impact of device parasitics, concepts in gate driver power supply design - bootstrapping and isolation, protection features - interlock protection, miller clamp and short circuit detection.

Power magnetics design : Design considerations for high frequency power transformers and inductors, core materials and their properties, winding strategies, parasitics and their impact, loss mechanisms – core and copper losses, loss modeling, thermal modeling.

Power converter design : Power converter performance degradation under line and load variations, practical examples, light load handling techniques, converter & controller design considerations to handle wide operating conditions.

Simulation Exercises: Free open source tools will be used for circuit simulations and FEA based simulations.

Learning Outcome: By the end of this course, students will be able to
1. Design gate driver circuits for Si-based and wide-bandgap semiconductors
2. Design high-frequency inductors and transformers.
3. Evaluate power converter design and performance trade-offs in practical applications.

Vishnu Mahadeva Iyer

Pre-requistes :

References : 1. Fundamentals of Power Electronics (3rd edition) by Robert W. Erickson and Dragan Maksimovic
2. Fundamentals of Power Semiconductor Devices (2nd Edition) by B. Jayant Baliga
3. Inductors and Transformers for Power Electronics by Alex Van den Bossche and Vencislav Cekov Valchev

E0 298 (AUG) 3 : 1

Linear Algebra and Its Applications

[A] Theory: Solution of linear equations, vector space, linear transformations, matrix representation, inner products and norms, orthogonality, trace and determinant, eigenvalue decomposition,symmetric (Hermitian) matrices and quadratic forms, singular value decomposition. [B] Applications: linear regression and normal equation, linearly constrained optimization, optimal subspace and low-rank approximations, dynamical systems, Markov chains, closest orthogonal transform, graph Laplacian and connectivity

Pavankumar Tallapragada , Vaibhav Katewa

Pre-requistes :

none.

References : [1] S. Axler, Linear Algebra Done Right, Springer, 2015. [2] C. Meyer, Matrix Analysis and Applied Linear Algebra, SIAM, 2000.

E9 222 (JAN) 0 : 3

Signal Processing in Practice

1. Introduction to Python, Matlab, Latex 2. Effective technical communication, content generation for reports 3. Discrete Fourier transform, cosine transform, Karhunen-Loeve transform 4. Noise types and their power spectra 5. Speech denoising using transform-domain processing 6. Short-time Fourier transform 7. Sampling 8. Linear prediction/autoregressive modeling 9. Basics of 5G and experiments using a network simulator (orthogonal frequency division multiplexing) 10. Image denoising and enhancement, edge-aware filtering, convolutional neural networks for image classification 11. Exercises on image processing and optimization for image recovery 12. Exercises on array signal processing, graph signal processing 13. Exercises on machine learning for a speech/image processing application

Sundeep Prabhakar Chepuri

Pre-requistes :

References : Lab Manual that will be prepared by the M.Tech.(SP) Program Curriculum Committee specifically for this course. In addition, the instructors will suggest selected reading material from the following references: 1. A. V. Oppenheim and R. W. Schafer, "Discrete-Time Signal Processing," Prentice Hall, 1999. 2. R. Gonzalez and R. Woods,"Digital Image Processing," Pearson, 2017. 3. L. R. Rabiner and R.

E1 248 (JAN) 3 : 0

Sliding mode control and its applications

Module 1: Preliminaries– 1. A brief introduction to state space representation 2. Controllability and observability 3. Fundamentals of nonlinear systems, linearization of nonlinear systems with examples 4. Stability analysis tool: Lyapunov's stability theorem, Lyapunov based control design Module 2: Sliding mode control–1.Theory of conventional sliding mode: Filippov theory, reaching laws, finite-time stability, equivalent control method, advantages of sliding mode control 2. Introduction to second order sliding mode: relative degree, twisting algorithm, super twisting algorithm (as controller, differentiator, and observer) 3. Higher order sliding mode (as continuous controller and differentiator) 4. Terminal sliding mode control: fast terminal sliding mode control, non singular terminal sliding mode, prescribed convergence law 5. Integral sliding mode control 6. Discrete-time sliding mode control: Gao's reaching law, Bartoszewicz's reaching law Module 3: Applications– Inverted pendulum, power convertors and power systems, quadrotors, etc. These will be covered as a part of the course project. Module 4: Optional topics : sliding mode observers, multi-rate output feedback based control.

Kiran Kumari

Pre-requistes :

References : 1. Sliding mode control and observation (Vol. 10. New York: Springer) by Yuri Shtessel, Christopher Edwards, Leonid Fridman, and Arie Levant, 2014. 2. Applications of sliding mode control (Vol. 79. Springer Singapore) by Derbel, Nabil, Jawhar Ghommam, and Quanmin Zhu, 2017. 3. Nonlinear systems (third edition) by Hassan K. Khalil, 2002.

E6 228 (AUG) 3 : 0

Grid Integration of Inverter-Based Energy Sources

Synchronous Generator operation, modeling and control, transient behavior modeling; short-circuit and symmetrical components. Three-phase two-level voltage source inverter (VSI), L-C-L filter design, sine and space vector PWM, common-mode voltage and current. Current-controlled grid following inverter, phase-locked loop (PLL), inverter modeling for current control; proportional-resonant controller, synchronous reference frame (d-q) control. Energy sources control, battery – P-Q control, PV – P-Q control, Active front end(AFE)–dc voltage and Q control; startup sequence and protection features of the inverter; LVRT and HVRT.Modeling of grid-connected inverter including PLL dynamics, Stability of operation at higher grid impedance. Voltage-controlled grid-forming model and control, voltage and frequency control; P-Q droop control. Utility-scale battery energy storage system (BESS), inertia and impedance of the power network; inertia emulation

Samir Hazra

Pre-requistes :
E6 201 Power Electronics or E6 202 Design of power converters or E3 252 Embedded System Design for Power Applications or E6 221 Switched Mode

References : (a) Grid Converters for Photovoltaic and Wind Power Systems, Remus Teodorescu; Marco Liserre; Pedro Rodriguez (b) Dynamics and Control of Electric Transmission and Microgrids, K. R. Padiyar, Anil M. Kulkarni

E1 250 (AUG) 3 : 0

Mathematics for Electric Power Engineers

Solving linear equations, row-reduced echelon form and Gauss elimination. Vector space, linear independence, basis, dimension, rank nullity theorem, orthogonality, the four fundamental subspaces, positive definiteness, singular value decomposition, pseudo inverse. Linear programming, simplex method, duality. Linear dynamical systems, eigen decomposition and Jordon form. Stability. Numerical solution of algebraic, root-finding algorithms such as Newton’s method.Unconstrained nonlinear optimization, first and second-order necessary conditions, steepest descent, and Newton’s algorithm. Constrained optimization, necessary conditions, Lagrange multipliers. Penalty, barrier, and constrained steepest descent algorithms. Sequential linear programming and quadratic programming. Nonlinear dynamical systems, existence and uniqueness of solutions, stability of equilibrium points-Lyapunov’s method, gradient and Hamiltonian systems, limit cycles: Poincaré Bendixson theorem.Numerical solution of differential equations, Euler and Runge-Kutta methods.Accuracy, stability, and convergence time

Kaushik Basu

Pre-requistes :

BTech Engineering Mathematics.

References : 1.Linear Algebra and Its Applications by Gilbert Strang. 2.Applied Linear Algebra by Peter J Oliver and, Chehrzad Shakiban. 3.Linear and Nonlinear Programming by David G Luenberger and, Yinyu Ye. 4. Differential Equations, Dynamical Systems, and an Introduction to Chaos by Morris W. Hirsch, Stephen Smale and, Robert L. Devaney. 5. Introductory Methods of Numerical Analysis by SS

E4 239 (JAN) 2 : 1

Multi-converter Power System Analysis

Overview of wind and solar generations; Grid Connection requirements for large scale Solar and Wind Farms including IEEE 2800 Standard; Basic principles of grid following and grid forming converters with LVRT, HVRT, negative sequence controls; Power Plant Controllers for Solar and Wind Farms; Load flow study in muti-converter power systems; Fault models of grid following and grid forming converters; Short circuit study with multiple converters; Modelling of grid following and grid forming converters for harmonic study; Harmonic analysis in presence of multiple converters; Modelling grid following and grid forming inverters for small signal and transient stability studies; Linear and non-linear stability assessment in presence of multiple converters; Sub-synchronous oscillations in presence of converters; Oscillation source identifications; Simulation assignments on grid following and grid forming inverter modelling for short circuit analysis, stability assessment, harmonic analysis, sub-synchronous oscillations and power flow study will be given as part of the laboratory work. There will be software simulation laboratory every week for 3 hours.

Sarasij Das

Pre-requistes :

E4 234: Advanced Power System Analysis

References : -“Grid converters for photovoltaic and wind power systems”. Teodorescu, Remus, Marco Liserre, and Pedro Rodriguez. John Wiley & Sons, 2011. -“Voltage-sourced converters in power systems: modeling, control, and applications”, Yazdani, Amirnaser, and Reza Iravani. John Wiley & Sons, 2010.

E6 240 (AUG) 3 : 0

Multilevel Inverters: Topology and Control

Motivation for MLIs, Voltage stress and waveform quality, Applications of MLIs; Basic Topologies: Neutral Point Clamped (NPC), Flying Capacitor (FC), Cascaded H-Bridge (CHB), Voltage level generation principles; Switching States and Operation Principles: Redundancies in MLIs, Symmetric vs Asymmetric MLIs; Modulation Techniques – I: Sinusoidal PWM (SPWM), Phase Disposition (PD), Phase Opposition (POD), Alternate Phase Opposition (APOD); Modulation Techniques – II: Space Vector PWM (SVPWM) for NPC and CHB, Harmonic performance analysis; Capacitor Voltage Balancing in FC and NPC: Active and passive balancing methods; Advanced MLI Topologies: Active NPC, T-Type, Packed U-Cell (PUC), Switched Capacitor MLIs (SCMLIs); Control Techniques: Open-loop control strategies, Carrier-based and reference-based control, Model Predictive Control; Fault Tolerance and Protection in MLIs: Fault types, detection and mitigation strategies; Industry Trends and Research Challenges: transformer-less MLI topologies for achieving compact and cost-effective designs, Analysis of Wide Band Gap devices (e.g., SiC, GaN) for high-efficiency MLI operation.

Tapas Roy

Pre-requistes :
Power Electronics (E6-201) or Equivalent

References : Text Books:
T1. “Multilevel Converters for Industrial Applications” by Sergio A. González, Santiago A. Verne, María I. Valla – Springer, 2014
T2. “Advanced DC/AC Inverters-Applications in Renewable Energy” by F. L. Luo and H. Ye, CRC Publications, 2017

Electronic Systems Engineering

Preface

E0 284 (AUG) 2 : 1

Digital VLSI Circuits

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

Viveka Konandur Rajanna

Pre-requistes : None

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

Prabhakar T V , Dagale Haresh Ramji , Joy Kuri

Pre-requistes : None

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

E2 243 (AUG) 2 : 1

Mathematics for Electrical Engineers

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

Joy Kuri , Chandramani Kishore Singh

Pre-requistes : None

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

E3 200 (AUG) 1 : 2

Microelectronics Lab

1. Device TCAD and Device Design Basics using TCAD: Device TCAD Models,Device Simulation Approach, Design of CMOS (nMOS/pMOS) devices using TCAD device simulations, Design of FinFET using device simulations,Analysis of Physical Parameters and Device Physics using TCAD, Parameter extraction from simulation results 2. CMOS Process Technology, Process Development, Integration and Simulation:Processing Steps - Lithography,Etching, Dopant Implantation,Material Deposition, Thermal annealing / Dopant Diffusion and Backend Metallization. TCAD Process simulation - Unit process simulation, process calibration, process integration,simulation of basic CMOS devices. TCAD simulation of standard cell library element, Advance CMOS device design,process simulation and process integration, Basics of 3D process simulation,Layout design for test chips development, Details of Mask writing and device fabrication 3. Semiconductor Device Characterization: Non-destructive and destructive characterization

Mayank Shrivastava

Pre-requistes : None

References : None

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

Pre-requistes : None

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 230 (JAN) 2 : 1

Essential Circuits for System Design

L Umanand

Pre-requistes : None

References : None

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. Verilog: 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, Artix - 7 architecture, programming FPGA, constraints, STA, timing closure, case study.

Debayan Das

Pre-requistes : None

References : Digital Design: Principles and Practices By J.F. Wakerly

E3 235 (AUG) 2 : 1

Design for Analog Circuits

Op-amp circuits: single-stage & multi-stage amplifiers; differential & instrumentation amplifiers; FB-topologies; i-v, v-i & impedance converters; current amplifier; Error budgeting: static and dynamic errors in op-amp circuits; Power supplies: precision rectifiers; voltage regulators & protection circuits; Active filters: LPF, HPF, BPF, BRF & APF; 1-pole, 2-pole and Butterworth; Instability: GM, PM, dominant-pole, pole-zero & roc compensation; Nonlinear circuits: hysteresis, schmitt-triggers & exponential circuits; Oscillators: relaxation/phase-shift/wien-bridge/voltage controlled oscillators; waveform generators; Practical designing: sensor amplifiers & damping; AGCs & compressor circuits; ADCs and DACs; photo-resistor & opto-coupler circuits; temperature indicators & PID-controllers; 4-20ma transmitters; ELF/VLF receivers. Lab exercises: understanding datasheets; circuit simulation using LTspice;

V Naga Krishna

Pre-requistes : None

References : Sergio Franco: "Design With Operational Amplifiers and Analog Integrated Circuits" McGraw-Hill Series; Peter D. Hiscocks: "Analog Circuit Design"; Online articles on: "Circuit Simulation with LTSpice"

E3 245 (AUG) 2 : 1

Processor System Design

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

Kuruvilla Varghese

Pre-requistes : None

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

E3 258 (AUG) 2 : 1

Design for Internet of Things

Introduction to IoT, Challenges in IoT - Power, Security, Identification, Location, Low Power Design, Energy harvesting systems, Power management algorithms, Working with ADC, DC-DC and LDO component datasheets, ARM processor low power features, multiprocessor systems, Lifetime estimation, RFID and its applications, Backscattering techniques, Working with protocols such as MQTT, COAP, for low power and energy harvesting sensor nodes, Low power wireless networks - Bluetooth Low Energy (BLE), and IEEE 802.15.4e TSCH. Low Power Wide Area Networks - LORA, NBIoT and power-saving modes, CAT-LTE-M1.

Prabhakar T V

Pre-requistes : None

References : RFCs, Application notes, Standards, Handbooks, Recent papers on selected topics.

E3 276 (AUG) 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

Hardik Jeetendra Pandya

Pre-requistes : None

References : None

E3 282 (AUG) 3 : 0

Basics of Semiconductor Devices and Technology

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

Santanu Mahapatra

Pre-requistes : None

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

E9 253 (JAN) 3 : 1

Neural Networks and Learning Systems

Introduction, models of a neuron, neural networks as directed graphs, networkarchitectures (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

Shayan Garani Srinivasa

Pre-requistes : None

References : None

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

Pre-requistes : None

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

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

Pre-requistes : None

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

ED 299 (JAN) 0 : 25

MTech ESE Dissertation Project

MTech ESE Dissertation Project

Chandramani Kishore Singh

Pre-requistes : None

References : None

E6 203 (AUG) 1 : 2

Mechatronics System Design

Mechatronics intro, bond graph modelling of mechatronic systems, sensors and circuits - voltage, current, temperature, pressure, velocity, position, angular velocity, flow, flow rate, torque, stress, strain, etc., electrical actuators and drive - moving iron,solenoids, relays, electric motors, servo motor, stepper motor, motor selection, mechanical actuators - kinematic chains, cam, gears,ratchet, clutches, flexible elements, brakes etc., interfacing microcontrollers with actuators, control of actuators, robotic manipulator, differential dynamic mobile robot

L Umanand

Pre-requistes : None

References : 1.System dynamics: A unified approach, Dean Karnopp and Ronald Rosenberg, John Wiley and Sons 2.Mechatronics:Principles and Applications, Godfrey C Onwubolu, Elsevier publishers, 2005, 3.Digital control of dynamic systems, Franklin, Powell and Workman, Addison-Wesley, 3ed

E0 204 (JAN) 2 : 1

Neuromorphic Analog VLSI design

Topic Contents Computational Neuroscience Neuron/Synapse models, Auditory and Visual pathways, Olfaction pathway Neuromorphic Engineering Introduction MOS Transistor, Sub-threshold operation of MOS Analog Circuit Fundamentals DC Analysis, Freq response, Feedback system, Gm/Id Methodology Synaptic devices (Optional) Floating gate, Memristor Static circuits Transcondutance Amplifiers, Current Mirror, Differential Pair, Gain Stages DC Operation Current-mode circuits Translinear Principle, Floating-Gate MOS Circuits, Bump Circuit, Current Multipliers Signal-Aggregation Circuit Centroid Circuits, Resistive Networks, Diffusor Circuits, Winner-Take-All Circuits, Delay Lines Basic elements of Neuromorphic electronics Electronic models of neuron, synapse and dendrites Neuromorphic Systems Electronic Cochlea, Auditory Localization, Silicon Retinas, Voltage and Current Mode Neuron Models, Address Event Communication, Motor Pattern Generatio

Chetan Singh Thakur

Pre-requistes :

References : • Peter Dayan and L. F. Abbott, Theoretical Neuroscience: Computational and Mathematical Modeling of Neural Systems, The MIT press, 2005. • Carver Mead, Analog VLSI Implementation of Neural Systems, Addison Wesley, 1989 • S.-C. Liu, J. Kramer, G. Indiveri, T. Delbrück, and R. Douglas, Analog VLSI:Circuits and Principles. Cambridge, MA: MIT Press, 2002. • Liu, S.-C., Delbrück, T.,

E3 203 (JAN) 2 : 1

Design of Analog Electronics and Industrial Instru

1. Sensors and transducers• Active and passive transducers• Transducer characteristics: temperature, pressure,flow,magnetic field, light 2. Sensor and transducer interfacing circuits: amplifiers• Wheatstone bridge• Amplifier characteristics – noise, linearity, supply rejection, impedance, range• Current/voltage/charge sensing circuits Instrumentation, transimpedance amplifiers 3. Analog signal processing: filters• Filter characteristics – magnitude and phase, ripple, group delay• Linear filters – Butterworth, Chebyshev 4. Interfacing circuits: drivers• Load type considerations – resistive and capacitive• Large current drive 5. Interface to digital processors: Analog to Digital Circuits• ADC characteristics – Data rate, ENOB, SFDR, INL, DNL• ADC architectures and choices – Flash, SAR, D-S, Pipeline 6.PIDand Programmable Logic Controllers 7. Digital communication interface– USB, I2C, USART

V Naga Krishna

Pre-requistes : None

References : Dally, J.W., et al., Instrumentation for Engineering Measurements, John Wiley and Sons, 1984.

E0 217 (AUG) 2 : 1

Efficient and Secure Digital Circuits and Systems

Circuits: overview of CMOS digital circuit design, logic gates, combinational and sequential logic, finite state machines, arithmetic circuits, memories, timing considerations, power consumption Systems: overview of computer architecture, instruction set,hardware-software interaction, micro-controllers, hardware acceleration, FPGA and ASIC design. Efficiency: gate-level optimization for power-performance-area, low-power versus energy-efficient implementation, pipelining, multi- level memories and caches. Security: introduction to cryptography and security protocols, implementation of multi-precision modular arithmetic, timing and power side-channel attacks and countermeasures

Utsav Banerjee

Pre-requistes :
Basic understanding of digital electronic circuits.

References : 1.M.M.Mano and M.D.Ciletti,"Digital Design," Pearson Education,2018. 2.J.M.Rabaey, A.P.Chandrakasan and B.Nikolic,"Digital Integrated Circuits: A Design Perspective," Pearson Education,2016. 3.Journal/Magazine Articles and Conference Papers.

ET 299 (JAN) 0 : 31

MTech EPD Dissertation Project

MTech EPD Dissertation Project

Chandramani Kishore Singh

Pre-requistes : None

References : MTech EPD Dissertation Project

E3 273 (AUG) 2 : 1

Microcontroller and its Applications

Microcontroller COTS boards Architecture: Raspberry Pi. AURDUINO, and others Raspberry Pi Board, Software Systems & Applications Arduino Boards, Software Systems & Applications Using Arduino with Raspberry Pi for Real Time Applications Laboratory : Using Raspberry Pi, Arduino Boards and Sensors for Engineering Applications.

Ramachandran P.

Pre-requistes : None

References : Exploring Raspberry Pi: Interfacing to the Real World with Embedded Linux Book by Derek Molloy

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 codes.

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. 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 and Robert Bosch Centre for Cyber Physical Systems. Department of Civil Engg and CiSTUP jointly offer an M Tech Programme in Transportation Engineering. Department of Management Studies offers a Master of ManagementProgramme. 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 Sciences

Society and Policy

Preface

Bioengineering

Preface

Educating a new breed of young researchers at the biology-engineering interface is the primary goal of the Interdisciplinary M. Tech and PhD Programme in Bioengineering. 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.

August Semester Courses
BE 203 Bioengineering Practicum I 0:1
BE 204 Bioengineering Practicum II 0:1
BE 207 Mathematical Methods for Bioengineers 3:0
BE 213 Fundamentals of Bioengineering 1 2:0
BE 219 Essentials of Research and Innovation 2:0
BE 206 Biology for Engineers 3:0
BE 210 Drug Delivery: Principles and Applications 3:0

Jan semester courses
BE 203 Bioengineering Practicum I 0:1
BE 204 Bioengineering Practicum II 0:1
BE 214 Fundamentals of Bioengineering 2 2:0
BE 215 Chemistry for Bioengineers 3:0
BE 229 Statistics for Bioengineers 1:0
BE 230 Data Science for Bioengineers 2:0
BE 299 MTech Dissertation Project 0:32
BE 211 Cell Mechanics 3:0
BE 216 Dynamical Systems Biology 3:0
BE 218 Computational Epidemiology 3:1
BE 222 Stem Cell Technology 3:0
BE 223 Space Biology and Bioengineering 2:0
BE 224 Diagnostics and Devices 3:0
BE 227 Synthetic Biology and Protein Engineering 2:0
BE 228 Introduction to Mathematical Oncology 3:0

BE 203 (AUG) 0 : 1

Bioengineering Practicum 1

Sanhita Sinharay , Ajay Sanjay Tijore

Pre-requistes : None

References : None

BE 204 (AUG) 0 : 1

Bioengineering Practicum 2

Sanhita Sinharay , Ajay Sanjay Tijore

Pre-requistes : None

References : None

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.

Rachit Agarwal , Ajay Sanjay Tijore

Pre-requistes : None

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 207 (AUG) 3 : 0

Mathematical Methods for Bioengineers

Mohit Kumar Jolly

Pre-requistes : None

References : None

BE 210 (AUG) 3 : 0

Drug Delivery: Principles and Applications

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. 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 stra

Rachit Agarwal

Pre-requistes : None

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

BE 213 (AUG) 2 : 0

Fundamentals of Bioengineering 1

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

Bhushan J Toley , Mohit Kumar Jolly

Pre-requistes : None

References : None

BE 214 (AUG) 2 : 0

Fundamentals of Bioengineering 2

This course covers essentials of biomaterials and cell and tissue 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.

Part I of the course will cover biomaterials: polymers (synthesis and properties), metals, ceramics, biocompatibility, biodegradability, key properties of biomaterials (mechanical, chemical and physical properties), protein adsorption, host response to biomaterials (innate immune response, blood coagulation and complement response), fibrosis, implant associated infections, drug delivery, tissue engineering

Part II of the course will cover cell and tissue mechanics: Cell and tissue types, Viscoelasticity of cells and tissues, mechanics of cells: cytoskeleton: contractility and movement, molecular motors for transportation within the cells, Signal transduction within the cells to achieve basic mechanics, cellular forces, stiffness sensing of cells, wound healing, mechanics of multi-joint posture and movement control

Rachit Agarwal , Medhavi Vishwakarma

Pre-requistes : None

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,

BE 215 (AUG) 3 : 0

Chemistry for Bioengineers

This course aims to provide a fundamental understanding of chemistry to bioengineers so they can harness these concepts to solve bioengineering research challenges. The main topics that will be covered in this course are the following: 1. Bonding models including valence bond theory, molecular orbital theory, chemical forces-types and applications on biological /bi ochemical reactions.(8 lectures) 2. Quantum chemistry and application to group theory, molecular orbital theory -applications to metals in biology and bioinorganic compounds (hemoglobin) and in molecular spectroscopy.(5lectures). 3. Physical chemistry involving concepts of equilibrium reactions, electrochemistry and chemical kinetics, acid-base chemistry and its subsequent application in biomaterials and disease diagnostics. (6 lectures) 4. Coordination Chemistry-Understanding transition metal chemistry, introductions to crystal field theory to understand reactivity of biologically relevant molecules such as cisplatin, c

Sanhita Sinharay

Pre-requistes :

References : References 1. Organic chemistry- Clayden, Greeves and Warren 2. A guidebook to mechanisms in organic chemistry- Peter Sykes 3. Inorganic chemistry-principles of structure and reactivity- James Huheey. 4. Molecular Quantum Mechanics- Peter Atkins 5. Physical Chemistry- Peter Atkin

BE 224 (JAN) 3 : 0

Diagnostics and Devices

Part I: In vitro diagnostics/devices (1.5)
The aim of this part is to gain a thorough understanding of technologies used behind most in vitro diagnostic tests conducted in pathology laboratories, as well as dive deeper into upcoming technologies that may transform in vitro medical diagnostics in the future. Broadly, this module will cover three areas:
1. Technologies: hematology analyzers, blood glucometers, immunoassays, lateral flow assays, nucleic acid amplification tests, microarrays, whole genome sequencing (10 lectures)
2. Applications: Infectious disease diagnostics, detection of antimicrobial resistance, cancer diagnostics (7 lectures)
3. Ethical clearances, pre-clinical submissions, and regulatory requirements (2 lectures)

Part II: In vivo diagnostics will focus on the following areas (1.5):
1. Diagnostic devices in the clinic – engineering principles of different radiology techniques- CT, ultrasound, MRI, PET, SPECT (5 lectures)
2. Chemistry of molecular imaging Radiochemistry of PET/SPECT, nanochemistry for molecular imaging, targeted antibodies and peptides, MRI probe development and ultrasound contrast agents (10)
3. Application of in vivo diagnostic imaging in field of cancer, cardiovascular disease, Central nervous system and autoimmune diseases (5 lectures).

Instructor: Bhushan Toley (Part I) + Sanhita Sinharay (Part II)

References
1. Molecular Imaging: Principles and practices – Ralph Weissleder

Additional information
The course is open to doctoral and master's students from all disciplines.
Course objectives
By the end of the course students will be able to:

1. Develop a good understanding of technologies used for conducting most laboratory diagnostic tests
2. Gain a sense of new in vitro diagnostic technologies that are currently in research stage
3. Evaluate the engineering principles involved in instrumentation of different diagnostic devices
4. Apply the understanding of molecular imaging in the clinic to assess its utility for disease diagnosis

Sanhita Sinharay

Pre-requistes : None

References : Molecular Imaging: Principles and practices – Ralph Weissleder

BE 222 (JAN) 3 : 0

Stem Cell Technology

The course will introduce students to the fundamental principles of stem cell science, stem cell functioning, clinical applications and bioethical issues associated with use of stem cells. Also, students will learn recent techniques to develop scaffolds and platforms to study stem cell differentiation in the context of regenerative medicines. The following topics will be covered: basic overview of stem cells including stem cells from other organisms, history of stem cell research, importance of stem cells, stem cell differentiation and methods to regulate stem cell differentiation, induced pluripotent stem cells (iPSCs) and lab technique to develop iPSCs, methods to use stem cells to study disease, stem cell-based therapies for regenerative medicines and the bioethics of stem cell research. In nutshell, students will learn what has been accomplished, what challenges remain and what potential breakthrough may lie ahead in the field of stem cells. The course lectures will be delivered by experts in each of the topics with occasional guest lectures from colleagues in the academia/ industry.

Ajay Sanjay Tijore

Pre-requistes : None

References : 1. Engineering Materials for stem cell regeneration, Faheem Sheikh, Springer Nature, 2021 2. The Science of Stem Cells, Slack Jonathan M.W Course material will include lecture notes (not provided, but taken by students during the lecture), a few slide-handouts (provided), and specific portions of texts recommended by the lecturers.

BE 299 (JAN) 0 : 32

MTech Dissertation Project

Dissertation project for M. Tech. students

Medhavi Vishwakarma

Pre-requistes : None

References : M. Tech. project work

BE 230 (JAN) 2 : 0

Data Science for Bioengineers

Bioengineering research often generates large amounts of data, analysis of which requires sound technical knowledge of data sciences. The goal of this course is to introduce students to the basic concepts and tools of statistical and machine learning, which may be useful to analyse the data generated by the medical, biological, and bioengineering community. The following topics will be covered: linear regression, analysis of categorical data, logistic regression, linear-discriminant analysis, resampling methods, decision trees, support vector machines, deep learning, unsupervised learning. Problems will be presented and solved using R.

Narendra M Dixit , Siddharth Jhunjhunwala

Pre-requistes :

1.Undergraduate level course in probability and statistics

References : There is no prescribed textbook for this course. But the following reference is suggested: 1. An Introduction to Statistical Learning, Gareth James et al.

BE 229 (JAN) 1 : 0

Statistics for Bioengineers

The goal of this course is to introduce students to the basic concepts and tools of statistics, which is essential to analyse data generated by the medical, biological, and bioengineering community. The following topics will be covered: introduction to descriptive statistics, discrete and continuous probability distributions, estimation, hypothesis testing including students ‘t’ test, ANOVA, and non-parametric tests. Problems will be presented and solved using R.

Narendra M Dixit , Siddharth Jhunjhunwala

Pre-requisites :

1.Undergraduate level course in probability and statistics

References : There is no prescribed textbook for this course. But the following reference texts are suggested: 1.Fundamentals of Biostatistics, Bernard Rosner

BE 227 (JAN) 2 : 0

Synthetic Biology and Protein Engineering

Part I: Concepts and practice of synthetic Biology; genetic engineering; synthetic biology in healthcare; basic research; environment; engineering. Impact of synthetic biology of culture and life. Evidences from Genetically engineered machines development through seminar series. Part II : Genetic Code Expansion and Protein Engineering: This part of the course explores the principles and applications of genetic code expansion, a powerful tool in synthetic biology and protein engineering. The course will cover the significant aspects of the molecular and cellular mechanisms underlying genetic code expansion, learn about the various methods for incorporating non-natural amino acids into proteins, and explore the diverse applications of this technology in areas such as drug discovery, receptor-ligand interaction, and biotechnology.

Saravanan Palani

Pre-requisites : None

References : “Expanding and reprogramming the genetic code”, Nature. 2017 Oct 4;550(7674):53-60. doi: 10.1038/nature24031. “Expanding the genetic code”, Annu Rev Biophys Biomol Struct. 2006:35:225-49. “A chemical toolkit for proteins--an expanded genetic code”, Nat Rev Mol Cell Biol. 2006 Oct;7(10):775-82. doi: 10.1038/nrm2005. “Expanding the genetic code for biological studies”, Chem

BE 301 (JAN) 3 : 0

AI for Biomedical Research

This course intends to build on the fundamentals of machine learning to explore concepts from these areas in the context biomedical research. Students will learn about applications of advanced approaches (like transformers, Graph Neural Networks, Large Language Models, or their combinations) for problems in biomedical data sciences. Motivating examples from cancer genomics, biomedical imaging, spatial transcriptomics and drug discovery will be used to examine these principles. The course will comprise instructor-led lectures, student presentations, and course projects. Schedule permitting, guest lectures from the Institute and companies (pharma, research labs etc) might also be incorporated.

Siddharth Jhunjhunwala

Pre-requisites :
Pre-Requisites (all 3 required):
1. BE-207 (Mathematical Methods for

References : There is no prescribed textbook for this course. Comprehensive reading lists are provided for each topic. Key references include:
- McElreath R. Statistical Rethinking: A Bayesian Course with Examples in R and Stan
- Van Der Maaten L, Postma E, Van den Herik J. Dimensionality Reduction: A Comparative Review

Nanoscience and Engineering

Preface

NE 200 (AUG) 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.

Supradeepa V R

Pre-requistes : None

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 202 (AUG) 0 : 2

Micro AND Nano Fabrication

This course is designed train student in device microfabrication at the cleanroom facility in CeNSE. The courses starts with eyes-on demonstration of the proces flow of a p-n junction solar cell or MOSFET. Next, the students will execute a microfabrication heavy project which exposes them to design-of-experiment, process development, and troubleshooting

Shankar Kumar Selvaraja , Sushobhan Avasthi

Pre-requistes :

NE203 or NE203A

References : None

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 and EM theory. Principle of thermal equilibrium, concept of entropy, Boltzmann factor, Blackbody radiation, H-atom, Wave nature, uncertainty principle, wave equation, application to particle in a box, scattering, different quantum numbers, Dirac notation and application to SHO Idea of operator and commutation Unitary operator, Hilbert space, Time independent perturbation theory, Fermi Golden rule, spin and statistics MB, FD and BE statistics, crystal structure, reciprocal lattice, lattice vibrations, free electrons, electrons in periodic potential, bands, quantization: photon, phonon, excitations, Maxwells equations in vacuum, insulating and conducting media, Fresnel equations Interference, diffraction and polarization quantum description Interaction of light with two level system

Chandan Kumar

Pre-requistes : None

References : Books for CMP/SSP part: Kittel, Ashcroft & Mermin Books for Quantum Mechanics: Grffiths Books for EMT: Griffiths

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 , Vini Gautam

Pre-requistes : None

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 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. Major emphasis will be placed on developing a wholistic view of MEMS and NEMS systems by not only giving consideration to physics of the device but also taking into account fabrication technologies required for manufacturing the device, readout circuits and other electronics and packaging. The course covers device fabrication techniques such as bulk and surface micromachining. Different levels of modelling such as back-of-the envelop calculations to solution of coupled partial differential equations solutions using FEM techniques will be discussed. A wide range of fundamental physicsneeded to design MEMS devices including, but not limited to, thermal circuits, linear and non-linear spring-mass damper systems, electrostatics, piezoresistivity, piezoelectricity etc. These concepts will be discussed in context of various practical MEMS and NEMS devices such as accelerometers, gyroscopes, micro-bolometers, timing-references, mass spectrometers etc. Finally, integration of micromachined mechanical devices with microelectronics circuits for complete implementation is also discussed.

Saurabh Arun Chandorkar , Gayathri Pillai

Pre-requistes : None

References : 1.Stephen D. Senturia, “Microsystem Design”, Kluwer Academic Publishers, 2ndPublishing, 2001. 2.G. K. Ananthasuresh, K. J. Vinoy, S. Gopalakrishnan, K. N. Bhat and V.K. Aatre, “Micro and Smart Systems”, Wiley India, 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-requistes : None

References : None

NE 231 (AUG) 3 : 0

Microfluidics

This is a foundation course discussing various phenomena related to fluids an fluid-interfaces at micro-nano scale. This is a pre-requisite for advanced courses and research work related to micro-nano fluidics. Transport in fluids,equations of change, flow at micro-scale, hydraulic circuit analysis, passive scalar transport, potential fluid flow, stokes flow Electrostatics and electrodynamics, electroosmosis, electrical double layer (EDL), zeta potential,species and charge transport, particle electrophoresis,AC electrokinetics Surface tension, hysteresis and elasticity of triple line, wetting and long range forces, hydrodynamics of interfaces, surfactants, special interfaces Suspensions, rheology,nanofluidics, thick-EDL systems, DNA transport and analysis

Prosenjit Sen

Pre-requistes : None

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 250 (JAN) 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.

Srinivasan Raghavan , Supradeepa V R

Pre-requistes : None

References : None

NE 312 (JAN) 3 : 0

Nonlinear and Ultrafast Photonics

Supradeepa V R , Varun Raghunathan

Pre-requistes : None

References : None

NE 313 (AUG) 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 de partment. 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 , Balaswamy Velpula

Pre-requistes : None

References : Anthony E. Siegman, Lasers, University Science Books (1986), OrazioSvelto, Principles of Lasers, Springer (2010),Miscellaneous Resea rch Articles and Reviews.

NE 314 (AUG) 3 : 0

Semiconductor Opto-electronics and Photovoltaics

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

Aditya Sadhanala

Pre-requistes : None

References : None

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-requistes : None

References : None

NE 316 (JAN) 3 : 0

Advanced Electron Microscopy in Materials Characterization

Review of resolution limits in microscopy. Aberration function. Correction of spherical aberration to various orders. Aberration probe correctors, Advances in detectors and direct electron detectors. High resolution STEM: Recap of Convergent Beam Electron Diffraction, idea of Ronchigram, integrating the electron wavefunction in various annuli of the Ronchigram. BF, ABF, L/MAADF, HAADF STEM. Recap of incoherent/ coherent scattering, ideas of Rutherford scattering (Z2 contrast in HAADF vs Z2/3 contrast in ABF) Case studies on simulation of images and extracting information from STEM images Information beyond annular integration. Imaging from the Ronchigram center of mass deviations. Linearity of potential transfer. 4 segment detectors and DPC imaging, Ptychography X-rays and inelastically scattered electrons–EDS and EELS In situ microscopy techniques (basics and discussion from research papers

Ravishankar Narayanan , Pavan Nukala

Pre-requistes :

References : •Scanning Transmission Electron Microscopy, Eds. Nellist and Pennycook •Transmission Electron Microscopy: Diffraction, Imaging, and Spectrometry- Companion volume to the TEM book by Williams and Carter •Advanced transmission electron microscopy: imaging and diffraction in nanoscience, 2017, Springer •Electron energy loss spectroscopy in the electron microscope, Egerton, Plenum

NE 281 (AUG) 3 : 0

Statistical and probabilistic data analysis techniques

This course will introduce foundational concepts in statistics and probability from an applied perspective suitable for experimentalists. The learning objectives are the application of stochastic models to aid data analysis, for instance, techniques for parameter estimation and hypothesis testing. Methods to simulate stochastic processes and solve first order stochastic differential equations will be covered. Physical processes such as random walks, chemotaxis, photon counting and single molecule sensing will be used to illustrate the theoretical concepts. Additionally, uncertainty analysis of experiments will also be covered. List of topics: Probability distributions of single r.v, PDF and CDF, , Moments, MGF, CGF, joint PDF, conditional distributions, conditional moments, Bayes theorem, PDFs of functions of r.v, Stochastic processes, simulating stochastic processes, Monte-carlo technique, auto-correlation and power spectra of random processes, estimation of PDF and CDF from data, Parameter estimation: estimators such as MLE, MMSE and Bayes, Cramer-Rao bound, Hypothesis testing: statistical significance, Neyman-Pearson approach, p-value, F-distribution, ANOVA, Bayesian inference, Case studies: Uncertainty and error analysis, Random walk and diffusion, Photon counting, Single molecule sensing

Manoj Varma

Pre-requistes : None

References : 1.Probability models in engineering and science, Haym Benaroya and Seon Mi Han, Taylor and Francis 2005 2.Applied statistical inference, Leonhard Held and Daniel Sabanes Bove, Springer 2014 3.Stochastic processes in cell biology, Paul C. Bressloff, Springer 2014

NE 240 (AUG) 3 : 0

Materials design principles for electronic, electromechanical and

Module 1:Structure and symmetry, property predictions from symmetry: piezoelectricity, electrostriction, ferroelectricity, second harmonic generation Module 2:Equilibrium property predictions from thermodynamics, order parameters elementary statistical mechanics of phase transitions, Landau theory, property enhancements near second order phase transitions Module 3:Dissipative properties, entropy generation, Onsager's formulation, hysteresis, electrical and thermal transport, electrical /thermal resistance, thermoelectric properties Module 4:Defects, kroger-vink notation, defects as property deteriorating entities, defects as property enhancing entities, Recent f indings on designing new properties through defects and their kinetics (revisit of ferroelectricity and electromechanical responses of defective compounds) Tight binding band structure, perturbation by defects, physics of amorphous solids and their electronic properties. Correlations (if time permits), and metal-insulator transitions.

Pavan Nukala

Pre-requistes : None

References : 1.Physical properties of crystals, J.F. Nye 2.Properties of materials, anisotropy, symmetry and structure, R.E.Newnham 3.Properties of non-crystalline solids, Mott and Davies 4.Research papers

NE 317 (JAN) 3 : 0

From natural to artificial intelligence

Artificial intelligence (AI) has been heralded as the flagbearer of the fourth industrial revolution. To implement AI, we need a technological breakthrough in computing hardware. The question is how we design those new generations of devices. This is where the idea of natural intelligence inevitably comes in. The Profuse dendritic-synaptic interconnections among neurons in a brain embed intricate logic structures enabling cognition and sophisticated decision-making that vastly outperforms any artificial electronic analogues. The physical complexity is far beyond existing circuit fabrication technologies: moreover, the network in a brain is dynamically reconfigurable, which provides flexibility and adaptability to changing environments. How about we capture these qualities in a new generation circuit element? That is the whole idea propelling the field of brain-inspired computing which is one of the cutting-edge technologies in development. While there are many courses on AI around the world there is no course where biology is directly correlated to device physics, and circuit design and that is the main idea behind the proposed course. The course will be taught by myself along with Professor Deepak Nair from CNS. Professor Nair will introduce the concepts of natural intelligence and how it is manifested in neuronal networks. The topic to be covered in under this thread are: data processing in neurons and synapses, synaptic plasticity, potentiation, depression, idea of spike time dependent plasticity, 'integrate and fire' response in a neuron, signal transmission through axons, plasticity, reconfigurability and redundancy in a neuronal network and finally, the origin and expression of intelligence in a neuronal circuit. Based on the biological foundation, I will develop the device and circuit design philosophy that is being taken for designing efficient AI hardware platforms. I shall introduce the static and dynamic elements being attempted to make a synapse and a neuron. The material and circuit properties to mimic the features of a neuron and a synapse will be covered. Different approaches such as FET, FTJs, memristors and neuristors will be introduced. We will discuss strategies to operate the circuit elements on the verge of chaos that can enable us to realize intelligence and decision-making ability on a chip. Towards the end of the curriculum, the students will be asked to come up with their own proposals to address specific challenges either at a device or a circuit level. This course could offer cutting-edge exposure and motivate students to take on some of the outstanding, high reward research challenges in this field.

Sreetosh Goswami

Pre-requistes : None

References : 1.Minds Behind the Brain: A History of the Pioneers and Their Discoveries 1st Edition 2.Origins of Neuroscience: A History of Explorations into Brain Function Reprint Edition 3.Principles of Neural Science (Kandel) 4.Brain-Inspired Computing by Amunts, Katrin, et al. (Springer) 5.CNN: A paradigm for Complexity 6.Brains Are Made of Memristors." Handbook of Memristor Networks. Springer, Cham,

NE 320 (JAN) 3 : 0

Quantum Optics

Quantum optics is a fundamental subject which describes the behavior of light and light matter interactions at the quantum level. Its only through quantum optics that many deep and often baffling observations with light are resolved. With the advent of quantum computing and quantum communications, quantum optics takes a primary role owing to its foundational contribution to both these applied areas. This course will be an introductory quantum optics course and below listed are some representative topics covered in the course. There will be additional time allocated to specific problems of current interest in the course. Topics 1.Quantization of the electromagnetic field 2.Vacuum fluctuations 3.Wave packet representation 4.Coherent states 5.Density operators and phase space 6.Atom-field interactions 7.Jaynes-Cummins Model 8.Dressed States 9.Von-Neumann Entropy 10.Coherence functions 11.Squeezed States 12.Bunching and Anti-bunching 13.Cat states and other forms of non-classical light 14.Tests of Quantum Mechanics 15.Introduction to cavity QED 16.Advanced topics in quantum measurements

Supradeepa V R , Chandrashekar C M

Pre-requistes :

References : 1.Introductory Quantum Optics by C. C. Gerry and Peter Knight, Cambridge University Press (2012) 2.Optical Coherence and Quantum Optics by Leonard Mandel and Emil Wolf, Cambridge University Press (2013) 3.Quantum Optics: An Introduction, by Mark Fox, Oxford Master Series in Physics (2007) 4.Various Research and Review Papers discussed in class.

NE 201B (JAN) 0 : 2

Lab for structural and functional characterization

This is a laboratory course designed to train students in various device and material characterization techniques. Following techniques will be covered under the course: XRD, electron diffraction and microscopy such as TEM, SEM, Elastic vs. inelastic Energy loss/spectroscopy/EELS, XPS/XAS. Photoluminescence, Raman Spectroscopy, Confocal and fluorescence microscopy, Optical profilometer/UV-vis/ellipsometer, basics of FTIR, Atomic Force Microscope, including CAFM, KPFM, Basics of electrical measurements including resistivity, 4-probe, Hall, TLM, van der Pauw, Capacitance-Voltage measurement including MOS C-V, theory and working of lock-in amplifier; low frequency highly sensitive measurements, Opto-electronics measurements including measuring detectivity, photo current and noise of photodetector, basics of LED measurements, Basics of high-frequency measurement – needle probe vs CPW, oscillos cope/function generator, basics of VNA and small-signal parameters

Akshay K Naik , Gayathri Pillai

Pre-requistes :

References : Notes

NE 352 (JAN) 3 : 0

Quantum transport in low dimensional materials

a.Basics of solid state physics: Drude theory, counting states, density of states, Fermi energy, Fermi Dirac distribution, conductivity and resistivity tensor b.Field-effect transistor, Ohmic and Schottky barrier, Metal semiconductor field effect transistor, Metal oxide semiconductor field effect transistor. c.Basics of Nanoscale device fabrication, photo-lithography, electron beam lithography d.Why Electron flow, Conductance formula, different transport regime: Diffusive, Ballistic, and hydrodynamic e.Conductance fluctuations, phase coherence length, Aharonov-Bohm and weak localization f.Quantum hall effect, edge current, Landauer Buttiker formalism, Subnikov de Hass effect, introduction to fractional quantum hall effect g.Quantum dot, Coulomb-Blockade, Quantum capacitance h.Introduction to Superconductivity and Josephson effect i.Introduction to local scanning probes techniques like single electron transistor (SET), superconducting quantum interference devices (SQUID), scanning tunneling microscopy (STM)

Chandan Kumar

Pre-requistes :

Exposure to solid state Physics course

References : 1.Solid State Physics by Neil Ashcroft, N. David Mermin 2.Mesoscopic Electronics in Solid State Nanostructures by Thomas Heinzel 3.Introduction to superconductivity by A.C Rose-innes and E.H Rhoderick

NE 201A (AUG) 3 : 0

Theory of structural and functional characterization

This course provides theoretical framework for various device and material characterization techniques. Following techniques will be covered under the course: XRD, electron diffraction and microscopy such as TEM, SEM, Elastic vs. inelastic Energy loss/spectroscopy/EELS, XPS/XAS. Photoluminescence, Raman Spectroscopy, Confocal and fluorescence microscopy, Optical profilometer/UV-vis/ellipsometer, basics of FTIR, Atomic Force Microscope, including CAFM, KPFM, Basics of electrical measurements including resistivity, 4-probe, Hall, TLM, van der Pauw, Capacitance-Voltage measurement including MOS C-V, theory and working of lock-in amplifier; low frequency highly sensitive measurements, Opto-electronics measurements including measuring detectivity, photo current and noise of photodetector, basics of LED measurements, Basics of high-frequency measurement – needle probe vs CPW, oscilloscope/function generator, basics of VNA and small-signal parameters

Akshay K Naik , Pavan Nukala , Gayathri Pillai , Vini Gautam

Pre-requistes :

References : Lecture notes

NE 303 (AUG) 2 : 1

Semiconductor Process Integration

The course teaches the art and science of semiconductor process integration. The courses will discuss module-level integration issues that come up in complex device fabrication. In the first 4 weeks, we will discuss technologically relevant modules like LOCOS, shallow trench isolation, replacement metal gate, Damascene and dual-Damascene, etc. In the next 9-10 weeks, we will discuss case studies on six advanced devices with complex fabrication flows. The basket of courses will change with time but examples include, leading-node logic, memory, integrated photonics, solar cells, microelectromechanical systems, light emitting device, and heterogenous integration. The course has 1 lecture per week of instructor-led teaching. The lecture will discuss case studies. In parallel, we will have weekly take-home lab-assignment on TCAD software like SEMulator3D. We will organise 1 take-home lab per week. The lab will be in the form of an assignment, where students will be required to submit a report, which will be graded. The lab session,will be supported by 1 tutorial session per week. The tutorial will be organised to help answer questions. It will be primary run by TA(s).

Navakanta Bhat , Shankar Kumar Selvaraja , Sushobhan Avasthi , Saurabh Arun Chandorkar

Pre-requistes :

NE203

References : 1. Introduction to Microfabrication by Sami Franssila, Wiley 2.Silicon Devices and Process Integration - Deep Submicron and Nano-Scale Technologies by Badih El-Kareh, Springer 3. Materials & Process Integration for MEMS, Francis E. H. Tay, Springer 4. Handbook of 3D Integration by Christopher Bower, Peter Ramm, Philip Garrou, Wiley Solar Photovoltaics Technology, System Design,

NE 203A (AUG) 3 : 1

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. Waferdicing, scribing and cleaving. Mechanical scribing and laser scribing,Wafer bonding, die-bonding. Wire bonding, die-bonding.Chip-mounting techniques. Simulation-based assignments on the above topics

Shankar Kumar Selvaraja , Sushobhan Avasthi

Pre-requistes : None

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 299A (JAN) 0 : 32

Dissertation Project

In the senate meeting earlier this year, for the incoming batch of Mtech students (Aug 2025), the dissertation project credits has been enhanced from the previous 0:27 to 0:32. We are currently in the process of getting the academic structure made for it. Since we would still have students from the earlier structure following the 27 credit project in the upcoming year, we are creating a new course code (NE299A) to incorporate the added credits. We were also told by the academic section and SAP people that this is advisable since two courses with the same code but different credits wont be appropriate for long term historical records.

Supradeepa V R

Pre-requistes : None

References : Dissertation Project

NE 241A (AUG) 3 : 1

Materials synthesis: from quantum dots to bulk crystals

1. Material thermodynamics: first, second, third laws; solution thermodynamics, phase diagrams, reaction thermodynamics, case studies in materials growth that use these principles 2. Role of surfaces in synthesis 3. Role of elasticity 4. Nucleation and growth, 3D 5. 2D Nucleation and growth 6. Thin film growth modes and techniques

Srinivasan Raghavan

Pre-requistes : None

References : 1. Class notes is the most important reference. Please pay attention in the class, take good notes. 2. Robert T DeHoff, Thermodynamics in Materials Science, 2nd Ed, Taylor and Francis 3. CHP Lupis, Chemical Thermodynamics of Materials, 1983, North Holland publishers 4. David Gaskell, Introduction to thermodynamics of materials, Fifth edition 5. Ballufi, Allen, Carter, Kinetics of Materials,

NE 206A (AUG) 3 : 1

Semiconductor Device Physics: Basic Devices

An graduate level course, NE206 provides an introduction to semiconductor device physics. The focus is on basics like the origin of band-structure, carrier transport, thermal statistics, junctions, defects, and interfaces. Schottky diodes, p-n junction diodes, bipolar junction transistors, and MOS transistors are covered in detail. This is a fundamental course for anyone interested in electronic devices. TThe lab component will use simulation-based assignments to complement the theory part of the course.Topics include, energy bands in solids; Fermi-Dirac distribution; doping; density of states; low-field transport; high-field transport; carrier flow by diffusion and drift; Excess carriers and recombination processes; PN junction at thermal equilibrium & bias; Transient behavior of p-n junction; metal- semiconductor (Schottky and Ohmic junctions; Current transport mechanisms; BJT; MOS capacitor; MOSFET; Short channel effects;advanced CMOS devices Laboratory component based on simulation assignments. Topics similar to above.

Navakanta Bhat , Sushobhan Avasthi

Pre-requistes : None

References : “Introduction to Semiconductor Materials & Devices”, by M.S.Tyagi "Physics of semiconductor devices", by S M Sze, Wiley Indi “Semiconductor Device Physics and Design”, by Umesh Mishra and Jasprit Singh, Springer “Physical Foundations of Solid State Devices”, by E. F. Schubert (e-book available free at http://nadirpoint.de/Physik_Lit_PDF/65.pdf)

NE 242 (JAN) 3 : 0

Nanotechnology in Biology and Medicine

This course introduces students to the fundamental principles of nanotechnology and its advanced applications in diagnostics, drug delivery, imaging, tissue engineering, and disease treatment. It covers an overview of nanotechnology, including its principles, the size and scale of nanomaterials, their unique properties, and the different types of nanomaterials and devices. Key topics include synthesis and fabrication methods, characterization techniques, and the interactions of nanotechnology with biological systems, such as cellular uptake, toxicity, and biocompatibility. The course also delves into the use of nanotechnology in diagnostics, highlighting biosensors and nanoparticles for imaging (MRI, CT, and fluorescence), and in drug delivery, focusing on targeted nanoparticle-based systems with case studies in cancer therapy and gene delivery. Additionally, it explores the role of nanomaterials in tissue engineering and regenerative medicine, including scaffold development, stem cell therapy, and applications in wound healing, bone repair, and organ regeneration. Emerging trends such as nanobots, personalized medicine, and precision therapies are discussed, alongside practical considerations for translating nanomedicine into clinical practice, including safety, ethical concerns, regulatory issues, and patenting.

Vini Gautam

Pre-requistes : Basic knowledge of concepts in biology, chemistry, and physics (undergraduate level)

References : o Nanomaterials and Nanotechnology in Medicine (Vishak et al, Wiley) o Nanotechnology: Science, Innovations and Opportunity (Foster et al, Person). o Research articles from pioneering journals in the field (Nature Nanotechnology, Nanomedicine, Advanced Healthcare Materials etc)

NE 369 (JAN) 2 : 2

Basic to Advanced Spectroscopy Techniques

This basic-to-advanced-level course would provide a comprehensive exploration of spectroscopy, starting from fundamental principles and advancing to complex applications in material science, chemistry, and physics. The course covers topics such as electronic transitions, UV-Visible spectroscopy, infrared (IR) spectroscopy, Raman spectroscopy, photoluminescence (PL), and advanced techniques like Time-Correlated Single Photon Counting (TCSPC) and Photoluminescence Quantum Yield (PLQY) measurements. The laboratory component provides hands-on experience with material deposition, sample preparation, lifetime measurements, PL mapping, and data analysis. This course equips students with practical skills and theoretical knowledge valuable for research and industry roles involving spectroscopic analysis and material characterization.

Manoj Varma , Aditya Sadhanala

Pre-requistes : Prerequisites • Basic courses in Physics and Chemistry. • Familiarity with quantum mechanics is recommended but not mandatory

References : Required Textbooks and Materials • "Principles of Fluorescence Spectroscopy" by Joseph R. Lakowicz • "Introduction to Spectroscopy" by Donald L. Pavia, Gary M. Lampman, and George S. Kriz • Lab Manual: Provided by the instructor • Software: Access to data analysis tools (e.g., Origin, MATLAB)

NE 209 (JAN) 3 : 1

Semiconductor Equipment Design and Development

Theory:

Process Flow and Equipment Types,
Layout and economics of wafer fabs,
Basics of vacuum technology,
Fundamentals of chemistry
Basics of fluid flow
Fundamentals of heat and mass transport
Basics of RF Systems
Fundamentals of stress analysis
Design for Safety
Wafer handling and robotics
System integration

Laboratory:
Electronics:
Soldering
Arduino basics
PID control - theory and setting up a PID circuits; temperature sensors, thermocouple
SCPI commands and interfacing a simple digital multimeter using labview and python.
Vacuum Technology
Vacuum sealing and leak detection
Rotary pump and its construction
Conductance flow in a system
Gas Box
Valves

Akshay K Naik , Supradeepa V R , Pavan Nukala , Sreetosh Goswami , Dhavala Suri

Pre-requistes : None.

References : 1. Fundamentals of Vacuum Science and Technology, Gerhard Lewin
2. Experimental Techniques at Low Temperatures, G. K. White

Computational and Data Sciences

Preface

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.

Debnath Pal

Pre-requistes : None

References : None

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.

Debnath Pal

Pre-requistes : None

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

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 , Chirag Jain

Pre-requistes : None

References : None

DS 252 (AUG) 3 : 1

Cloud Computing

Distributed Systems Foundations.
Cloud Service and Deployment Models.
Virtualization and Container Runtimes.
Cloud Storage Services and Scaling Costs.
Serverless Orchestration.
Cloud Security & Policies.
DevOps & Observability.
Cloud-Native MLOps Pipelines.
Edge Computing & Edge–Cloud Continuum.
Emerging topics on Agentic Cloud Workflows, Quantum Computing in the Cloud.

Yogesh L Simmhan

Pre-requistes : CS major in undergraduate, Introduction to Scalable Systems, or any other prior systems course.

References : LLM Agents guided by course curriculum framework.
Notes and papers.

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-requistes : None

References : None

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

Pre-requistes : None

References : Current Literature

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, Iter

Phani Sudheer Motamarri

Pre-requistes : None

References : None

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 optimizat

Ratikanta Behera

Pre-requistes : None

References : None

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 we

Konduri Aditya

Pre-requistes : None

References : None

DS 290 (AUG) 3 : 0

Modelling and Simulation

Soumyendu Raha

Pre-requistes : None

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

DS 295 (JAN) 3 : 1

Parallel Programming

1) Architecture: computer organization, single-core optimizations including exploiting cache hierarchy and vectorization, parallel a rchitectures 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. 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 a

Sathish S Vadhiyar

Pre-requistes : None

References : None

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.

Phani Sudheer Motamarri , Sanchari Sen

Pre-requistes : None

References : None

DS 202 (JAN) 2 : 1

Algorithmic Foundations of Big Data Biology

(0) Introduction: basics of biological data, high-throughput DNA/RNA sequencing and associated biotechnological breakthroughs, data structures and algorithms warm-up(1) Exact string pattern matching: Z algorithm, Knuth-Morris-Pratt and Boyer-Moore(2) Genome-scale index structures: suffix tries and suffix trees, Burrows-Wheeler Transform, FM-Index(3) Approximate string pattern matching: Hamming distance, edit distance, dynamic programming, pairwise and multiple sequence alignment (4) Alignment-free sequence comparison: co-linear chaining problem, whole-genome comparison (5)Genome assembly: de Bruijn graphs, overlap graphs, haplotype assembly and phasing (6)Pattern discovery: Hidden Markov models, gene finding(7)Phylogenetics: algorithms for evolutionary tree reconstruction, distance-based phylogeny, neighbour-joining algorithm (8)Trending topics: cancer genomics, deep learning in genomics, transcriptomics,single-cell omics, population genomics

Chirag Jain

Pre-requistes :

Knowledge of basic data structures, algorithms, programming
References : Gusfield, Dan. "Algorithms on stings, trees, and sequences: Computer science and computational biology." ACM Sigact News 28.4 (1997): 41-60. Durbin, Richard, et al. Biological sequence analysis: probabilistic models of proteins and nucleic acids. Cambridge university press, 1998. Jones, Neil C. and Pavel Pevzner. An introduction to bioinformatics algorithms. MIT press, 2004. ·

DS 392 (JAN) 3 : 1

Environmental Data Analytics

Data-Driven Modelling in the Geosciences: Problem Formulation and Computational Modeling Approaches. Handling and Analysing Spatiotemporal Geoscience Data (Remote Sensing, In-situ instruments, Primitive Equation Models). Hands-on Applications of Supervised (Linear Methods, Nonlinear Methods) and Unsupervised Learning (Clustering, Dimensionality Reduction) in Environmental Analytics. Hands-on Applications of Deep Learning (Multi-Layer Perceptron, Convolutional and Recurrent Architectures) in Remote Sensing of the Natural Environment. Bayesian Inference and Data Assimilation for Physics-based Dynamic Data-driven Environmental Systems. Reinforcement Learning for Ocean Sensing.Case studies based on recent literature.

Deepak Narayanan Subramani

Pre-requistes :
DS 211 (Numerical Optimization), DS 221 (Introduction to Scalable Systems), DS 284 (Introduction to Numerical Linear Algebra), or
References : 1. Géron, Aurélien. Hands-on machine learning with Scikit-Learn, Keras, and TensorFlow: Concepts, tools, and techniques to build intelligent systems. Second Edition. O'Reilly Media, 2019. 2. Särkkä, Simo. Bayesian Filtering and Smoothing. Cambridge University Press,2013. 3. Murphy, Kevin P. Machine Learning: A Probabilistic Perspective. MIT Press, 2012

DS 269 (JAN) 2 : 1

Computational Methods for Reacting Flows

This three-credit course that comprises two parts. 1. Solver design: Governing equations: conservation of mass, momentum, energy and species. Low mach number and fully compressible formulations. Non-dimensional numbers. Discretisation methods: finite difference and finite volume. Introduction to chemical kinetics: global and elementary reactions, Arrhenius equation, chemical time scales, stiffness. Elements of a solver development: initial and boundary conditions, simulation algorithms, verification and validation Dimensionality reduction: principal component analysis, higher order moment tensors. Regression methods for thermo-chemical coefficients 2. Data analytics: DNS database analysis: premixed and non-premixed turbulent flames, modes of combustion, flame structure, turbulence chemistry interactions, chemical explosive mode analysis Machine learning based analysis: flame surface extraction, detection of combustion instabilities

Konduri Aditya

Pre-requistes :
Basic knowledge in combustion (AE 241 or equivalent), numerical methods for differential equations (DS 289 or equivalent) and machine learnin(E0
References : 1. An Introduction to Combustion, Stephen R. Turns, McGraw Hill, 2011. 2. Theoretical and numerical combustion, Thierry Poinsot and Denis Veynante, RT Edwards Inc., 2005. 3. Data-Driven Science and Engineering: Machine Learning, Dynamical Systems, and Control, J.Nathan Kutz and Steven L. Brunton, Cambridge University Press, 2019.4. Research papers, material/notes provided by

DS 393 (JAN) 3 : 1

High-performance computing for Quantum Modeling of Materials

This four-credit course is designed to train research students with the relevant theory, numerical algorithms and scalable implementation aspects underlying the state-of-the-art computational techniques for quantum modelling of materials. Emphasis will be laid on the computational methods pertinent to today's exascale era. Syllabus:- Review of classical mechanics and postulates of quantum mechanics, System of identical particles, Notion of Slater Determinant, Hartree Fock Theory, Density Functional Theory equations (DFT), PAW formalism for pseudopotential DFT, Density Functional Perturbation Theory. Review of state-of-the-art numerical discretization strategies for electronic structure calculations, Iterative eigenvalue algorithms for large-scale electronic structure calculations, Scalable methods for DFT using finite-elements, Configurational force approach for computing atomic forces and periodic unit-cell stresses

Phani Sudheer Motamarri

Pre-requistes :

Background in Numerical Methods/Linear
References : Richard M Martin: Electronic Structure - Basic Theory and Practical Methods, Second Edition, Cambridge University Press 2020. Zhaojun Bai, James Demmel, Jack Dongorra, Axel Ruhe: Templates for the Solution of Algebraic Eigenvalue Problems, A Practical Guide, SIAM Publishers Morton E. Gurtin: Configurational Forces as Basic Concepts of Continuum Physics --- Research Papers, Material/

DS 215 (AUG) 3 : 0

Introduction to Data Science

Course Description: This three credit course will be offered every August - December term as a hardcore course in the Dept. of Compu tational and Data Sciences (CDS). This is designed to be an introductory graduate level course (200-series) with an aim to equip first year graduate students (M.Tech./Ph.D.) with the necessary fundamentals as well as various statistical tools and techniques to analyze, estimate, learn and infer from data. At the end of the course, the students should be able to parse a real-world data analysis problem into one or more computational components learned in this course, apply suitable statistical inference/machine learning techniques and analyze the results obtained to enable optimal decision making. This would also act as a first course in data science and provide necessary prerequisites and knowledge to explore more specialized and involved topics in machine learning, analytics, statistics etc. Detailed Syllabus:- Probability and Statistics Primer: Fun

Anirban Chakraborty

Pre-requistes :
Undergraduate level knowledge of linear algebra, multivariate calculus, numerical methods, basic programming skills (in any programming

References : 1. Athanasios Papoulis and S. Unnikrishna Pillai, Probability, Random Variables and Stochastic Processes, McGraw Hill Education, 2017. 2. Alberto Leon-Garcia, Probability, Statistics, and Random Processes for Electrical Engineering, 3rd Edition, Pearson, 2008. 3. Steven M. Kay, Fundamentals of Statistical Signal Processing, Volume I: Estimation Theory, Pearson, 1993. 4. Jerome H.

DS 298 (JAN) 3 : 1

Random Variates in Computation

This course is aimed at introducing graduate students to random variate generation, and statistical methods in computation with continuously varying numbers. Basic sets of operations namely linear algebra, integration of functions, and evaluation of statistical parameters are addressed in high-dimensions where a purely numerical approach may either be unviable or significantly less efficient. The following is a brief description of the contents of the coursework.

Topics:

Part I - Random variate generation: Descriptive statistics; probability distributions; convergence of samples; concentration inequalities; operations on random variables and transformations; variates using inverse transform method; numerical stability of inversion; rejection sampling; scaling of rejection sampling with number of dependent variables; acceptance-complement method; linear transformations of multivariate distributions; specialized algorithms. (4 weeks)

Part II - Randomized numerical linear algebra: Background material in NLA; randomized SVD approximations and low-rank projections; matrix norm estimation; approximate matrix multiplication; single-view/streaming approximations of a matrix; randomized solution of linear system of equations and linear regressions. (4 weeks)

Part III - Random sampling and integration/estimation: Monte Carlo sampling; brief note on quasi-Monte Carlo (QMC) and deterministic sampling; Markov Chain Monte Carlo (MCMC) methods - Gibbs sampler, Metropolis type updates, and Hamiltonian dynamics; high-dimensional integration using MCMC; non-convex domains and integration using N-Sphere Monte Carlo (NSMC); stopping and confidence intervals; scaling of methods with number of dimensions; example problems and applications. (4 weeks)

Murugesan Venkatapathi

Pre-requistes :

References : 1. Luc Devroye, Non-uniform random variate generation, Springer-Verlag, New York 1986.

2. Martinsson, P. and Tropp, J., Randomized numerical linear algebra: Foundations and algorithms, Acta Numerica 29, 403-572 (2020).

DS 261 (AUG) 3 : 1

Artificial Intelligence for Medical Image Analysis

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. Learning outcomes: On successful completion of the course, the student should be able to: Identify the basic c

Vaanathi Sundaresan

Pre-requistes :
Basic knowledge of Systems and Signals, Proficiency in Python, C/C++.

References : Main Text Books: Kevin Zhou, Medical Image Recognition, Segmentation and Parsing: Machine Learning and Multiple Object Approaches, Elsevier, 1st Edition - December 2, 2015 Jon Krohn, Grant Beyleveld, Aglaé Bassens, Deep Learning Illustrated: A Visual, Interactive Guide to Artificial Intelligence, Addison Wesley, 2019 Guest Lecturers by Prasad S. Murthy (GE Healthcare) (http://

DS 285 (JAN) 3 : 1

Tensor Computations for Data Science

Unit-1: Fundamentals: Basic concepts of matrix properties: norms, rank, trace, inner products, Kronecker product, similarity matrix. Fast Fourier transform, diagonalization of matrices. Toeplitz and circulant matrices with their properties (eigenvalue and eigenvector), block matrix computation, and warm-up algorithms.

Unit-2: Introduction to Tensors: Tensors and tensor operations: Mode-n product of a tensor. Kronecker product of two tensors, tensor element product, tensor trace, tensor convolution, tensor quantitative product, Khatri-Rao product, the outer product. The Einstein product and t-product tensors. The explicit examples include identity tensor, symmetric tensor, orthogonal tensor, tensor rank, and block tensor.

Unit-3: Tensor Decomposition: Block tensor decomposition, Canonical Polyadic (CP) decomposition, the Tucker decomposition, the multilinear singular value (the higher-order SVD or HOSVD) decomposition, the hierarchical Tucker(HT) decomposition, and the tensor-train (TT) decomposition. Eigenvalue decomposition and singular value decomposition via t-product and the Einstein product. Truncated tensor singular value decomposition. Tensor inversion, and Moore-Penrose inverse. power tensor, solving system of multilinear equations.

Unit-4: Applications of Tensor decompositions: Low-rank tensor approximation, background removal with robust principal tensor component analysis, image deblurring, image compression, compressed sensing with robust Regression, higher-order statistical moments for anomaly detection, solving elliptic partial differential equations.

Unit-5: Tensors for Deep Neural Networks: Deep neural networks, Tensor networks and their decompositions, including, CP decomposition, Tucker decomposition, Hierarchical Tucker decomposition, Tensor train and tensor ring decomposition, Transform-based tensor decomposition. Compressing deep neural networks.

Ratikanta Behera

Pre-requistes :

References : References (Books) (1) Liu, Y. (Ed.). Tensors for Data Processing: Theory, Methods, and Applications. Academic Press. (2021) (2) Liu Y, Liu J, Long Z, Zhu C. Tensor Computation for Data Analysis. Springer; 2022. Recent Articles (1) S. Ragnarsson and C. F. Van Loan. Block tensor unfoldings. SIAM J. Matrix Anal. Appl., 33(1):149–169, 2012. (2) T. G. Kolda. Orthogonal tensor decompositions.

DS 207 (JAN) 3 : 1

Introduction to Natural Language Processing

Text classification, word representations, n-gram language models, feed forward networks, recurrent neural networks, LSTMs, basics of optimization, sequence-to-sequence models, machine translation, attention mechanism, transformer architecture, pre-training, post-training through reinforcement learning (RLHF, DPO), scaling laws, decoding algorithms, tokenization, evaluation, ethics, diffusion models and its applications to language modeling.

Aditya Gopalan , Danish Pruthi

Pre-requistes :

References : 1. Speech and Language Processing (3rd ed. draft) by Dan Jurafsky and James H. Martin
2. Introduction to Natural Language Processing by Jacob Eisenstein
3. Neural Network Methods for Natural Language Processing by Yoav Goldberg

DS 216 (JAN) 3 : 1

Machine Learning for Data Science

Foundations of machine learning:
• Review of ML fundamentals: Un/semi/self-supervised learning, feature-based clustering, model fitting, linear regression, Generalized linear models, Discriminative models: logistics regression, discriminant analysis basics, regularization (2 weeks)
• Unsupervised/supervised ML techniques: Clustering techniques; Expectation maximization (EM) - K-Nearest Neighborhood classifiers, Gaussian Mixture Models, Generalized EM; Representation learning; Supervised ML methods: kernel-based methods - support vector machines, ensemble methods: Classification and regression trees (CART), boosting/bootstrap aggregation, Bayesian networks - hidden Markov models, Conditional random fields. (4.5 weeks)
• Dimensionality reduction techniques: Principal component analysis (PCA), linear discriminant analysis (LDA), T-Stochastic Neighborhood Estimation (TSNE), independent component analysis (ICA). (1.5 week)
• Deep learning basics: Computational graphs, feedforward networks, loss functions, convolutional neural networks, backpropagation, optimization, feature saliency and visualization, convolutional neural networks, encoder-decoder models, graph-based models, generative models. (2 weeks)

ML applications and statistical evaluation:
• Classification, segmentation and decision-making: Template matching, correlation – audio/speech signals; Regression and classification on publicly available sensory/survey data, image segmentation & classification - machine learning classifiers, feature-based and rule-based decision making, uncertainty estimation. (1 week)
• Evaluation of analysis tasks: Evaluation metrics, segmentation evaluation metrics (IoU, Dice, Jaccard indices, Hausdorff distance measures), classification evaluation metrics (confusion matrix, sensitivity, specificity, accuracy), registration metrics (MSE, MAE). (1 week)
• Testing statistical significance of ML applications: Review of hypothesis testing basic, permutation tests, effect of sample size, parametric and non-parametric tests, Shapiro-wilks test, t-tests. Statistical evaluation of ML applications: Descriptive statistics (mean, standard deviation, median, confidence interval, IQR), Unpaired and paired t-tests, one-way and repeated measures ANOVA. (2 weeks)

Practicals:

• Implementation of linear and logistic regressions, least square fitting, under/overfitting, regularization, LDA
• Scikit-learn: ML classifiers, comparison of unsupervised/supervised ML classifiers on data, feature ranking, feature reduction, Pytorch/tensorflow: deep learning parameter tuning, training regime, feature visualization/ saliency. Python: Statistical tests (t-test/ANOVA).

Vaanathi Sundaresan

Pre-requistes :

References : • C.M.Bishop, Pattern Recognition and Machine Learning, Springer, 2006,
• I. Goodfellow, Y. Bengio and A. Courville: Deep Learning, 2016.
• Jerome H. Friedman, Robert Tibshirani and Trevor Hastie, The Elements of Statistical Learning, Springer, 2001.

DS 307 (AUG) 3 : 0

Ethics In AI

We interact with AI technology on a daily basis—such systems answer the questions we ask (using Google, or other search engines), curate the content we read, unlock our phones, allow entry to airports, etc. Further, with the recent advances in large language and vision models, the impact of such technology on our lives is only expected to grow. This course introduces students to ethical implications associated with design, development and deployment of AI technology spanning NLP, Vision and Speech applications.

Specifically, this seminar course would facilitate discussions among students structured around pre-selected readings on topics related to ethics in AI.

Danish Pruthi

Pre-requistes :

The class is intended for graduate students and senior

References : 1. Fairness and Machine Learning: Limitations and Opportunities by Solon Barocas, Moritz Hardt, Arvind Narayanan

2. Custodians of the Internet: Platforms, Content Moderation, and the Hidden Decisions That Shape Social Media by Tarleton Gillespie

DS 363 (AUG) 3 : 1

Topics in Visual Analytics

This course aims to provide an introduction to research topics in the area of computer vision and machine learning and would be beneficial for students who are pursuing or intend to pursue research in the aforementioned area. We shall read and discuss an eclectic mix of classic and recent research papers on topics including (but not limited to) object and scene recognition, grouping, segmentation, pose modelling, motion estimation and visual tracking, activity recognition, 3D scene representation and understanding, vision and language models, deep generative models, vulnerabilities of deep vision models and mitigation strategies, zero/few-shot learning, domain adaptation, continual learning for vision tasks etc. This predominantly paper-reading style course would be interspersed with lectures/tutorials clarifying the fundamentals needed to assimilate the more advanced topics. Students will also need to complete significant hands-on projects towards successful completion of the course.

Venkatesh Babu R , Anirban Chakraborty

Pre-requistes :

References : As we shall mainly read and discuss research papers in this course, it would not have any prescribed textbook. The main resource would be the current literature. The following books would be useful as references and also to help with the pre-requisites, if needed –

DS 246 (AUG) 1 : 2

Generative and Agentic AI in Practice

Foundations: Environment setup, LLM API integration, basic prompt engineering Advanced Prompting: Few-shot learning, chain-of-thought, system prompts, production practices LangChain: Chains/agents, memory systems, custom tools, external integrations RAG & Vectors: Vector DBs, embeddings, semantic search, chunking strategies Fine-tuning & Deployment: LoRA/QLoRA, datasets, production deployment, monitoring Capstone Project.

Sashikumaar Ganesan

Pre-requistes :
Prerequisites: Python programming experience Basic understanding of machine learning concepts Familiarity with software development

References :
Textbooks:
1. LLMs in Production: From language models to successful products. Christopher Brousseau and Matthew Sharp. MEAP Publication 2024 ISBN 9781633437203

Management Studies

Preface

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].

Shashi Jain

Pre-requistes : None

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

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.

M Mathirajan

Pre-requistes : None

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

MG 201 (AUG) 3 : 0

Managerial Economics

Introduction to managerial economics, demand theory and analysis, productiontheory, 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.

Sumirtha Gandhi

Pre-requistes : None

References : Allen,Bruce et al: Managerial Economics: Theory,Applications,and Cases,WW Norton

MG 202 (AUG) 3 : 0

Macroeconomics

Macroeconomics: Overview, national income accounting, measurement of GDP in India, inflation and its measurement, price indices in India, aggregate demand and aggregate supply. India's macroeconomic crisis: causes and dimensions.Keynesian Theory, money and banking. How banks create money. Monetary Policy: Its instruments and uses, monetary policy in India, monetarism, supply side fiscal policies, Philipp's curve and theory of rational expectations. Case studies on macroeconomic issues.

Bala Subrahmanya Mungila Hillemane

Pre-requistes : None

References : Ministry of Finance: Economic Survey,Government of India,Recent Issues.,Froyen,Macroeconomics: Theories and Policies

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 salaryadministration, 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.

Shashi Jain

Pre-requistes : None

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

MG 212 (AUG) 2 : 1

Behavioral Science

Understanding human behaviour; functionalist, cognitive, behaviouristic and social learning theories; perception; learning; personality; emotions; defense mechanisms; attitude; communication; decision making; groups and social behaviour; intra-personal and inter-personal differences; managing conflicts.

Anjula Gurtoo

Pre-requistes : None

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

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-requistes : None

References : None

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.

Shashi Jain

Pre-requistes : None

References : None

MG 251 (AUG) 3 : 0

Finance and Accounts

Nature and purpose of accounting, financial statements: learning, understanding the basic financial statements. Preparation of P and L account,balance sheet, basic accounts and trial balance. Income measurement, revenue recognition, depreciation accounting. Cash flow statements. Analysis and interpretation of financial statements; concepts and elements of cost,activity based costing. CVP analysis, break-even point, marginal costing,relevant costing. Cost analysis for decision making: opportunity cost concept, dropping a product, pricing a product, make-or-buy and product mix decisions.Joint products, by- products. Process costing. Standard costing, budgeting – flexible budget, master budget, zero based budgeting. Overview of Financial Management, time value of money, fund and cash flow statement, risk and return. Working capital management: estimating working capital, financing working capital, receivables management, inventory management, cash management, money markets in India. Capital Budgeting: appraising long term investment projects, make vs. buy investment decisions, estimating relevant cash flow. Capital Structure: Estimation of cost of debt, cost of equity, overall cost of capital, CAPM. Capital structure planning: Capital structure policy and target debt equity structure, EBIT-EPS analysis. Leasing. Introduction to valuation of firm. Introduction to derivatives.

Shashi Jain

Pre-requistes : None

References : None

MG 258 (JAN) 3 : 0

Financial instruments and risk management strategies

Shashi Jain

Pre-requistes : None

References : None

MG 265 (AUG) 3 : 0

Data Mining

Introduction to data mining. Data mining process. Association rule mining:Apriori and FP tree. Classification: ID3, C4.5, Bayes classifier. Clustering:K-means, Gaussian mixture model. Bayesian belief networks. Principal component analysis. Outlier detection.

Parthasarathy Ramachandran

Pre-requistes : None

References : Jiawei Han and Micheline Kamber, Data Mining: Concepts and Techniques, Morgan Kaufman Publishers 2001.,Richard J. Roiger and Michael W Geatz, Data Mining: A Tutorial-Based Primer, Addison-Wesley 2003,Mehmed Kantardzic, Data Mining:Concepts, Models, Methods and Algorithms, Wiley, 2003

MG 277 (JAN) 3 : 0

Public Policy Theory and Process

Introduction to policy; conceptual foundations; practice of policy making; theories: social, institutional rational choice, punctuated equilibrium, and stages; frameworks and models; government and politics; rationality and governance; role of rules, strategies, culture and resources; member dynamics (institutional and non-institutional); analysis: meta, meso decision and delivery levels.

Anjula Gurtoo

Pre-requistes : None

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 , Bala Subrahmanya Mungila Hillemane

Pre-requistes : None

References : Dorf,Richard C.,Technology,humans,and society: toward a sustainable world

MG 298 (JAN) 3 : 0

Entreperneurship for Technology Start-ups

Bala Subrahmanya Mungila Hillemane

Pre-requistes : None

References : None

MG 301 (JAN) 3 : 0

Methodology of Management Research

Sumirtha Gandhi

Pre-requistes : None

References : None

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.

Shashi Jain

Pre-requistes : None

References : None

MG 229 (AUG) 3 : 0

Regression and Time Series Analysis

Review of Regression and Best Linear Prediction. Simple and Multiple Linear Regression - Uniformly Minimum Variance Unbiased Estimation, General Linear Hypotheses Testing, Prediction. Correlation Analysis - Simple, Multiple and Partial Correlations. Model Building - Feature Selection, Interactions, Transformations, Dummy Variable Techniques, Residual Analysis. Classical Decomposition of Time Series into Trend, Cyclical, Seasonal and Irregular Components. Stationary Stochastic Processes. Autocorrelation, Partial Autocorrelation, Impulse Response and Forecast Functions of Moving Average, Auto Regressive and ARMA Processes. Fitting ARMA Models. Trend Modeling - Deterministic versus Stochastic Trends, Integrated Processes, Unit Root Tests. Fitting, Interpreting and Forecasting using ARIMA Models. Seasonality Modeling – SARIMA Models.

Mukhopadhyay C

Pre-requistes : MG220 or equivalent

References : • Applied Linear Statistical Models by Michael H. Kutner,Christopher J. Nachtsheim, John Nete and William Li,,McGraw-Hill, International Edition.
• Introduction to Time Series and Forecasting by Peter J. Brockwell Richard A. Davis. Second Edition, Springer.

MG 220 (JAN) 3 : 0

Introductory Statistics

Statistical Inference - Estimation, Hypothesis Testing & Forecasting. Frequentist Sampling Distribution. Point Estimation Criteria - MSE, Unbiasedness, Standard Errors, Consistency, Sufficiency. Exponential Family of Distributions. Uniformly Minimum Variance Unbiased Estimation. Point Estimation Methods - Method of Moments & Method of Maximum Likelihood. Confidence Intervals. Statistical Hypothesis Testing - Type I & Type II Errors, Size and Power of a Test, Neymann-Pearson Lemma, Uniformly Most Powerful Tests, Uniformly Most Powerful Unbiased Tests. Fixed Significance Level Testing versus Observed Significance Level (p-value) Testing. Likelihood Ratio Tests. Sampling Distributions for Normal Populations - χ2, t and F Distributions. Inference for the Mean and Variance of a Normal Population – z, t and χ2 Tests and Intervals. Comparison of Means of two Normal Populations – Pooled, Welch and Paired t. Distribution-free Methods – Wilcoxon Rank Sum, Sign and Wilcoxon Signed Rank Tests, Empirical CDF and its Properties. Tests for Normality. Inference for Population Proportions – One Sample, Two Sample and Multi-Sample Problems – z-Tests; χ2 Tests for Goodness of Fit, Homogeneity and Independence; Fisher’s Exact Test and McNemar’s Test.

Mukhopadhyay C

Pre-requistes : MG219 or equivalent

References : • Statistical Inference by George Casella and Roger L. Berger. Second Edition, 2001. Duxbury.
• Applied Statistics and Probability for Engineers by Douglas C. Montgomery & George C. Runger. Fifth Edition, 2014. Willey.
• Statistics by David Freedman, Robert Pisani & Roger Purves. Fourth Edition, 2010. Viva Books.

MG 219 (AUG) 3 : 0

Introductory Probability Theory

Interpretation of Probability. Definition of Probability Space. Combinatiorial Probability. Probability Laws - Complementation, Addition and Multiplication Law. Conditional Probability. Bayes Theorem. Random Variables – Probability Mass Function, Probability Density Function, Cumulative Distribution Function, Moments & Quantiles. Chebyshev’s Inequality. Jointly Distributed Random Variables – Joint, Marginal & Conditional Distributions, Covariance, Correlation & Regression. Properties of Expectation, Variance, Covariance, Correlation and Regression. Probability Generating Function, Moment Generating Function and Characteristic Function. Discrete Probability Models – Bernoulli, Binomial, Hypergeometric, Geometric, Negative Binomial and Poisson Distributions. Poisson Process. Continuous Probability Models – Uniform, Exponential, Gamma, Beta, Weibull and Normal Distributions. Almost Sure, in Probability, in Moment and in Distribution Convergence of Random Variables. Law of Large Numbers. Central Limit Theorem.

Mukhopadhyay C

Pre-requistes : Multivariable Calculus and Linear Algebra

References : • A First Course in Probability by Sheldon Ross. Eighth Edition, 2010. Prentice Hall.
• Introduction to Probability Theory by Paul G. Hoel, Sidney C. Port and Charles J. Stone. 1971. Houghton Mifflin.
• Elementary Probability Theory with Stochastic Processes by Kai Lai Chung. Third Edition, 1974. Narosa Publishing House.

Energy Research

Preface

The academic programs (MTech (Res) and PhD) in the Energy Research centre are aimed towards advancing knowledge and skills related to the design of efficient energy conversion and storage processes and devices, utilization of energy resources- conventional fossil fuels to renewable sources such as solar, and waste-energy harvesting, and materials discovery and engineering. The program is open to students with diverse backgrounds in engineering and sciences and focus on equipping and training students to contribute to India's energy transition.

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.

Pradip Dutta , Aninda Jiban Bhattacharyya , Praveen Ramamurthy

Pre-requistes : None

References : None

ER 207 (JAN) 3 : 0

Optimal design of energy systems

Thermodynamics and entropy review. Guoy-Stadola theorem, exergy (physical and chemical), component-level 2nd law efficiency. Non-equilibrium thermodynamics, flux and conjugate driving forces, local entropy generation density. Economics of energy systems: CapEx vs. OpEx trade-off, limiting cases and parasitic losses. Power-plant design and optimal resource allocation. Multi-variable optimization, constrained optimization, introduction to calculus of variations. Balancing for energy efficient design. examples from heat exchangers, cryogenic systems, desalination technologies (reverse osmosis, multi-effect distillation, humidification-dehumidification). Control strategies for energy-optimal operation, with examples from air-conditioning.

Jaichander Swaminathan

Pre-requistes : None

References : Adrian Bejan, George Tsatsaronis, Michael J. Moran, Thermal Design & Optimization (2012), John Wiley & Sons

ER 208 (JAN) 3 : 0

Introduction to Micro Energy Harvesting

Introduction to micro energy harvesting. Micro energy harvesting using piezoelectric, triboelectric, electrostrictive, flexoelectric, and electrostatic electromechanical couplings. Micro-electromechanical systems (MEMS), nanogenerators, and sensors. Hydrovoltaic energy harvesting from water interaction with materials using water waving, evaporation, moisture, drawing, reverse electrodialysis, and reverse electrowetting processes. Pyroelectric, thermoelectric, magnetoelectric effects-based micro energy harvesting. Radio Frequency (RF) and non-RF micro energy harvesting. Materials in micro energy harvesting, roles of material design in the enhanced energy harvesting performance, basics of micro energy harvesting device fabrication, and applications of micro energy harvesting. Recent developments, renewability, and sustainability in micro energy harvesting.

Farsa Ram

Pre-requistes : None

References : Book:
1. Micro Energy Harvesting by Danick Briand, Eric Yeatman, Shad Roundy, Link: https://www.wiley.com/en-us/Micro+Energy+Harvesting-p-9783527672929

ER 210 (AUG) 3 : 0

Heat and Mass Transfer

Techniques to solve the heat equation: Simplification, Superposition, Separation of variables, Similarity solutions. Modelling approaches for real systems. Multi-dimensional unsteady conduction: product solutions. Boundary layer momentum, energy equations - Falkner-Skan transformation, Graetz problem. Natural convection heat transfer. Turbulent heat transfer. Radiation - Spectral, directional effects, interacting media. Mass transfer - Analogy to heat transfer, low mass transfer rate assumption. Simultaneous heat and mass transfer: evaporation, wet-bulb temperature.

Jaichander Swaminathan

Pre-requistes : None

References : 1. Heat Transfer, A. F. Mills
2. A Heat Transfer Textbook, Lienhard and Lienhard, https://ahtt.mit.edu/

ER 202 (AUG) 3 : 0

Thermodynamics of Energy Systems

Laws of thermodynamics, Application to processes (batch and steady-state) involving pure species, Concepts of availability and exergy, Property packages and computational tools for thermodynamic analysis, Equation of state, Maxwell's relations, Chemical equilibria and ionization, Gibbs and Helmholtz functions, Psychrometrics, Power and refrigeration cycles, Rational efficiencies of heat engines, Waste heat recovery, Fuel cells, Nozzles and blade passages, Introduction to gas turbines.

Pramod Kumar

Pre-requistes : None

References : Fundamentals of Thermodynamics. Borgnakke, Sonntag. Wiley
Fundamentals of Engineering Thermodynamics. Moran, Shapiro, Boettner, Bailey. Wiley
Advanced Engineering Thermodynamics. A Bejan. Wiley

ER 209 (AUG) 3 : 0

Introduction to Scientific Communication

Critical thinking, reasoning, and hypotheses in scientific communications. Characteristics of academic writing - abstract, literature review, paper, project report, invention disclosure and IP. Academic style guides for research reporting. Writings for fellowships, travel grants, and job applications. Importance of aesthetics (including figures, schematics, infographics, tables, posters, presentations, etc.). Guidelines for literature review in publications and theses. Literature search and reference management systems. Ethics and plagiarism including representing copyrighted information. Use of language editing tools and AI-based scientific search tools. Tools for effective workplace communication.

Farsa Ram

Pre-requistes : None

References : 1. Scientific Writing and Communication by Angelika H. Hofmann, 5th Edition, Oxford University Press
2. The Elements of Style by William Strunk Jr. and E.B. White, 4th Edition, Pearson

ER 212 (JAN) 3 : 0

Convection Heat and Mass Transfer

Modes of heat and mass transfer, differences between thermodynamics and heat/mass transfer, and connection to fluid mechanics, fundamental governing equations (conservation of mass, momentum, energy, and species transport), dimensionless numbers (Reynolds, Prandtl, Nusselt, Schmidt, Sherwood, Grashof, Rayleigh),concepts of hydrodynamic, thermal, and concentration boundary layers; boundary layer approximations and order of magnitude analysis, laminar external forced convection, integral method, internal forced convection, laminar free and mixed convection, Rayleigh Benard convection, concepts of mass diffusion, analogies between heat, mass, and momentum transfer, simultaneous Heat and Mass Transfer with applications to evaporation or drying processes. Introduction to turbulent convection, micro scale convection and special topics.

Pramod Kumar

Pre-requistes :
Knowledge of differential equations (PDE, ODE), understanding of Fluid mechanics, Heat transfer, and Thermodynamics. Preferably the student

References : 1) A. Bejan, “Convection Heat Transfer,” John Wiley.
2) L. Burmeister, “Convective Heat Transfer,” John Wiley.
3) W. M. Kays and M. E. Crawford, “Convective Heat and Mass Transfer”, McGraw Hill.

Water Research

Preface

WR 201 (AUG) 2 : 1

Watershed Modeling

Course description: This course will cover the concepts of watershed modeling. This three-credit course will be offered as an elective every year in the August-December term in the ICWaR. This course is aimed to be an introductory graduate-level (200-series) course, typically with Water Resources Engineering background. In-class lectures include basic and advanced topics related to surface hydrology. Additionally, the basics of computer methods in hydrology will be discussed. Tutorial sessions on MATLAB, MS Excel, and ArcSWAT will be conducted. Calibration and validation of ArcSWAT (distributed model) and HYMOD (lumped model) will be performed during tutorial sessions. Topics 1. Introduction to watershed modeling Runoff generation and streamflow. Spatio-temporal scales in watershed modeling. Watershed properties. 2. Pre-processing of model inputs Understanding watershed model inputs. Basics of MATLAB computations. Hydrologic data processing in MATLAB. 3. Data-driven watershed models Stochastic models (ex: Quantile regression). Neural network models. 4. Different watershed models Lumped/ Distributed/ Physical/ Conceptual watershed models. Thornwaite-type water balance model. Thomas model (abcd) model. Data assimilation in abcd model. Introduction to ArcSWAT and HYMOD. Flood forecasting. Performance measures. 5. Predicting the future Future hydrologic projections. Impact of climate change on river discharge. Uncertainty in river discharge estimation. Tutorial Sessions Processing of Geospatial and temporal data for watershed modeling. MATLAB tutorials. ‘abcd’ model set-up in MS Excel. Stochastic and NN model setup in Matlab. Calibration and validation of HYMOD and ArcSWAT. Development of forecast models.

Rajarshi Das Bhowmik

Pre-requistes :

Nona

References : Textbooks: Dingman, S. L. (2015). Physical hydrology. Waveland press. Singh, V. P., & Frevert, D. K. (Eds.). (2010). Watershed models. CRC press.

WR 202 (JAN) 3 : 0

Geodetic signal processing

A brief introduction to physical and satellite Geodesy, Geodetic data and Earth's surface processes, data from GRACE satellite mission, Introduction to filtering, Kalman filter, Regression, time-series decomposition, moving window averages, introduction to data as similation, Spherical harmonic analysis and synthesis, GRACE data processing, Global mass change trends, estimating Ice-sheet mass change, estimating groundwater change from satellites, closing the water and sea level budget.

Bramha Dutt Vishwakarma

Pre-requistes :
MATLAB or Python, ES 220 (would help but not compulsory), Linear algebra

References : 1. Torge, W., & Müller, J. (2012). Geodesy. In Geodesy. de Gruyter. 2. Chui, C. K., & Chen, G. (2017). Kalman filtering (pp. 19-26). Berlin, Germany: Springer International Publishing. 3. Jekeli, C. (1996). Spherical harmonic analysis, aliasing, and filtering. Journal of Geodesy, 70(4), 214-223. 4. Draper, N. R., & Smith, H. (1998). Applied regression analysis(Vol. 326). John Wiley & Sons. 5. Tapley,

WR 203 (AUG) 2 : 1

Applied geochemical modeling and Water quality analysis

Simulation and modelling • Introduction to the Storm Water Management Model (SWMM) in Urban Catchments (4 hr) • Tutorial on BRAT (Basic Radar Altimetry Toolbox) (4 hr) • Tutorial on Remote Sensing (4 hr) • Introduction to Climate/Earth System Modeling (4 hr) Basic electronic instrumentation (6 hr) Measurements of ionic contaminants using an ICPMS and IC (6 hr) Water Quality (1 hr) • To assess the alkalinity of a given water sample. (1 hr) • Determine chloride ion concentration in a water sample. (1 hr) • To assess the total solids of a given sample of water. (1 hr) • Measure Total hardness using dye indicators. (1 hr) • To introduce concepts of total coliforms using the multiple-tube fermentation technique. (2 hr) • To assess the color of the given water sample. (1 hr) • Determine the DO content of a given sample. (1 hr) • To assess the pH value of the given water samples. (1 hr) • To assess the residual chlorine of the given water sample. (1 hr)

Praveen Ramamurthy

Pre-requisites :
None

References : ITM User's Manual available at the web site http://web.engr.oregonstate.edu/~leon/ITM.htm

Chavez, P.S., 1996. Image-based atmospheric corrections-revisited and improved. Photogramm. Eng. Remote Sens. 62, 1025-1036.

WR 204 (JAN) 3 : 0

Aqueous Geochemistry

The focus of this course is to develop an understanding of the chemical compositions of natural waters, emphasizing both physiochemical and biogeochemical processes operating in aqueous systems: equilibrium vs. kinetic controls, redox reactions, aqueous complexes, chemical weathering, solute sources, and mass balances in watersheds, etc. Moreover, the application of stable and radiogenic isotope geochemistry used for fingerprinting processes that control water chemistry (rivers, oceans, groundwater) will be discussed. Simple hydrogeochemical modelling techniques will also be introduced. 1. Introduction to the hydrosphere: water cycle, catchment hydrology mass balance, biogeochemical cycles 2. Aqueous chemical reactions: Equilibrium and kinetic concepts, acids& bases, redox, adsorption-desorption, speciation and complexes, organic reactions and interactions. 3. Isotope geochemistry: stable isotopes (O, H, C and N), stable metal isotope systems (Ca, Mg, Li, Fe, etc.), radiogenic isotopes (Rb-Sr, etc.) applications in natural aquatic systems. 4. Weathering: silicate and carbonate chemistry 5. Composition of natural waters: rivers, oceans, groundwater, global issues 6. Hydrogeochemical modelling techniques: mixing models, source apportionments, etc.

Praveen Ramamurthy

Pre-requisites : None

References : 1. Donald Langmuir (1997), Aqueous Environmental Geochemistry. Prentice Hall.
2. Carol Kendall and Jeffrey J. McDonnell (Eds) (2006), Isotope Tracers in Catchment hydrology. Elsevier.
3. William M. White (2013), Geochemistry. Wiley-Blackwell.

Cyber Physical Systems

Preface

The Center for Cyber-Physical Systems focuses on interdisciplinary areas including robotics, control and optimization, mobility and urban intelligence, and energy management. The courses are designed to provide good theoretical background and hands-on experience in these areas. The center offers three programs - PhD, MTech (Research) and MTech in Robotics and Autonomous Systems.

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 systembasics 4.EMI/ EMC considerations 5.Network connectivity

Pandarasamy Arjunan

Pre-requistes : None

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

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 trans

Shishir Nadubettu Yadukumar

Pre-requistes : None

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

CP 220 (AUG) 2 : 1

Mathematical Techniques for Robotics Systems

Linear Algebra Basics: Matrices, Vector Spaces, Independence, Rank, Mappings Analytic Geometry Basics: Inner products, norms, orthonormal basis, projections, rotations Matrix Decomposition: Determinant &. Trace, Eigenvalues and vectors, Cholesky decomposition, Eighen Decomposition, Singular Value decomposition Vector Calculus: Gradients of functions and matrices, Backpropagation and Automatic Differentiation Floating point arithmetic, Optimization Basics: Gradient Descent, Constrained optimization, Convex Optimization. Probability and Stats Basics: Conditional Probability & Independence, Discrete distributions, Continuous distributions, Hypothesis Testing, Computational Techniques: Linear Regression, Density Estimation, Monte Carlo Methods.

Bharadwaj Amrutur

Pre-requistes : None

References : Mathematics for Machine Learning, M P Deisenroth, A Aldo Faisal, Cheng Soon Ong

CP 316 (JAN) 2 : 1

Real-time Embedded Systems

The course is organized in three parts: standalone (OS less)systems, multi-tasking systems with RTOS and systems with embedded OS.The course involves significant programming in C on embedded platforms running RTOS / embedded Linux. Part 1: Standalone systems: Software architecture: control loop, polling and interrupt driven systems, PID control and finite state machine Experiments: interfacing sensors and actuators to implement a standalone control system on an ARM based hardware platform. Part 2: Multi-tasking systems: Introduction to real-time systems, multitasking, scheduling, inter-task communication, memory management and device drivers. Experiments: build a multitasking system involving multiple simultaneous activities involving computing algorithms, IO processing and a user interface. Part 3: Embedded Linux: Building an embedded Linux system; processes and threads, memory management, file-system, drivers. Real-time limitations and extensions.

Bharadwaj Amrutur

Pre-requistes :

References : Real-time and Embedded Guide, Herman Bruyninckx https://www.cs.ru.nl/lab/xenomai/RealtimeAndEmbeddedGuide-Bruyninckx.pdf Embedded Linux Primer: A Practical Real-World Approach, Christopher Hallinan Embedded Systems - Shape the World: Valvano and Yerraballi http://users.ece.utexas.edu/~valvano/Volume1/E-Book

CP 230 (JAN) 2 : 1

Motion Planning for Autonomous Systems

(Theory) Motion planning in discrete space; Logic-based planning methods; Geometric representations; Kinematic chains and rigid and non-rigid transformations; Configuration space; Topological space concepts; Obstacles; Collision detection and avoidance in relative velocity space; Collision cones and velocity obstacles; Artificial potential fields; Flocking; Formation control; Sampling based motion planning; Collision detection, incremental sampling and searching, Rapidly exploring random trees, roadmap methods; Combinatorial motion planning; Complexity. (Laboratory) Path planning infrastructure in software; Planning space representation through vector constructs, Discretization of planning space, sampling the planning space, node-graph representations; Grid search based planning (A* algorithm); Forward and inverse kinematics, obstacle representations; planning complexity,Various heuristics for A* algorithm;Sampling based planning (RRT & RRT* algorithms); Path planning using RRT;

Pradipta Biswas

Pre-requistes :

References : 1.S.M. LaValle, Planning Algorithms, Cambridge University Press,2006. 2.M.Mesbahi and M.Egerstedt, Graph Theoretic Methods in Multiagent Networks, Princeton Series in Applied Mathematics,2010. 3.J.-C. Latombe, RobotMotion Planning (Vol. 124). Springer Science & Business Media, 2012. 4.Current Literature

CP 260 (JAN) 2 : 1

Robotic Perception

Module 1: Probabilistic Techniques State Estimation & Bayesian Inference Parametric and Non-parametric Filters for Sensor Signal Processing. Kalman filter and its variants, Use of simple motion models with wheel and IMU odometry in the assignments. Robotic Localization &Perception Laboratory Exercises for each of the above Module 2: Introduction to Deep Learning Techniques Deep feedforward networks Convolutional Neural Networks Recurrent Networks Laboratory Exercises Module 3: Case Studies onPerception for Robotics Basics of Image Processing and Manipulation. Basics of low-level vision, filtering, feature extraction, etc. Object Detection and SegmentationPose estimation and semantic segmentation. Visual Odometry and Localization Visual SLAM. Introduce fusion of point cloud data and lidar data with RGB. Laboratory Exercises for each of the above.

Bharadwaj Amrutur

Pre-requistes :

References : Probabilistic Robotics, S. Thrun Deep Learning, I Goodfellow Richard Szeliski, Computer Vision: Algorithms and Applications, Springer, 2010 (For the vision part).

CP 218 (JAN) 2 : 1

Theory and Applications of Bayesian Learning

Descriptive Statistics, Introduction to Probabilities, Bayes Rules, Probability Distributions, Maximum Likelihood Estimation, Bayesian Regression and Classification, Expectation-Maximization,Frequentist vs Bayesian Learning, Conjugate Priors, Graph Concepts, Bayesian Belief Networks, Probabilistic Graphical Models (PGMs), Probabilistic and Statistical Inferencing, Bayesian Estimation, Structure Learning, Bayesian Optimization, Markov Random Fields, Markov Chain Monte Carlo, PGM examples and applications (including industry and smart cities applications).

Punit Rathore

Pre-requistes :

References : Probabilistic Graphical Models, Principles and Techniques,1st edition, Daphne Koller, Cambridge University Press,2009. Machine learning: A Probabilistic Perspective, Kevin Murphy, MIT Press, 2012. Pattern Recognition and Machine Learning, Christopher Bishop, New York, Springer, 2006. Bayesian Reasoning and Machine Learning, David Barber, Cambridge University Press, 2012

CP 232 (AUG) 2 : 1

Swarm Robotic System

Modeling and simulation of dynamical systems - drones, ground robots (wheeled) and underwater robots, automatic control design, position and attitude tracking control using PID techniques, autonomous operations - take-off, landing, speed and steering control, behaviour control - obstacle avoidance and path planning, group autonomy, swarm behaviour - strategy, self-organization and emergence, task allocation, target actuation - cooperation and coordination in payload transfer, decision making under uncertainty

Suresh Sundaram , Jishnu Keshavan

Pre-requistes :

References : 1. Instructor's lecture notes
2. Autonomous Robots, George Bekey, MIT Press, 2006.
3. Heiko Hamann, Space Time Continuous Models of Swarm Robotic Systems, Springer 2010

CP 275 (JAN) 2 : 1

Formal Analysis and Control of Autonomous Systems

This course will provide an end-to-end overview of different topics involved in designing or analyzing autonomous systems. It begins with different formal modeling frameworks used for autonomous systems including state-space representations (difference equations), hybrid automata, and in general labeled transition systems. It also discusses different ways of formally modeling properties of interest for such systems such as stability, invariance, reachability, and temporal logic properties.
As a next step, the course will cover different techniques on the verification of such systems including Lyapunov functions, reachability, barrier certificates, and potentially model checking. Finally, the course will introduce students to several techniques for designing controllers enforcing properties of interest over autonomous systems.

Pushpak Jagtap

Pre-requistes :

References : • E. A. Lee and S. A. Seshia. Introduction to Embedded Systems: A Cyber-Physical Systems Approach. MIT Press, 2017.
• C. Belta, B. Yordanov, and E. Göl. Formal Methods for Discrete-Time Dynamical Systems. Springer International Publishing, 2017.
• C. Baier and J. P. Katoen. Principles of Model Checking. MIT Press, 2008.

CP 299 (JAN) 0 : 26

MTech Project

Project work under guidance of advisor(s)

Pushpak Jagtap

Pre-requistes : None

References : As per supervisor's recommendation

CP 320 (AUG) 3 : 0

Operations Research for Mobility Management

This course will introduce operations research (OR) techniques applied to cyber-physical systems (CPS), with an emphasis on decision making for mobility management. Urban mobility is evolving from a fixed supply chain that delivers process-driven travel to a dynamic ecosystem that delivers on-demand services. This new mobility model requires optimization across multiple systems such as transportation, parking, electric vehicle charging and vehicle-to-grid services, etc. The complexity, therefore, arises from the large scale of operations; heterogeneity of system components; dynamic and uncertain operating conditions; and goal-driven decision making and control with time-bounded task completion guarantees. The focus in this course will be on various classical optimization techniques and learning to optimize approaches that can be applied to solve operational problems at scale in the urban mobility domain. Examples of some decision questions include planning/ scheduling charging operations for a fleet of electric vehicles; dynamic pricing for charging demand management; electric vehicle route planning for last-mile delivery of goods and other valued-added services (such as selling energy back to the grid); operations management of mixed fleet of vehicles; etc. Selective operations research topics such as linear programming and combinatorial optimization; dynamic programming; sequential decision making under uncertainty; reinforcement learning; etc.; will be covered to understand the mathematical concepts for problem solving in mobility management. This course will be relevant to both computer science and electrical engineering students, as well as benefit those specializing in cyber physical systems and sustainable transportation

Punit Rathore

Pre-requistes :
A preliminary understanding of mathematical programming would be helpful, but no prerequisites are assumed.

References : • Wayne L. Winston (2003). Operation Research: Applications and Algorithms • Nocedal and Wright (2006). Numerical Optimization (Springer Series in Operations Research) • Norving and Russel (2010). Artificial Intelligence: A Modern Approach (Prentice Hall Series in Artificial Intelligence) • Sutton and Barto (2018). Reinforcement Learning: An Introduction

CP 241 (AUG) 2 : 1

Applied Linear and Nonlinear Control

Linear Systems - Mathematical representation of dynamical systems, State-space and input-output representations, Time response of homogeneous and non-homogeneous systems, Stability, Controllability and observability, State feedback controllers and pole placement, State observers, LQR control, PID control

Nonlinear Systems – Mathematical background for nonlinear systems, Equilibrium points, Essential nonlinear phenomenon like finite escape time, multiple isolated equilibria, limit cycle, chaos etc. Lyapunov and input-state stability, Control Lyapunov functions, Feedback linearization, Model predictive control

Lab - Simulation of linear, nonlinear, and hybrid control systems, Phase-space visualizations, Implementation of different controllers on various robotics and autonomous systems.

Pushpak Jagtap

Pre-requistes :

References : 1. A Linear Systems Primer by Antsaklis and Michael, Birkhauser, 2007.
2. Linear Systems Theory by Hespanha, Princeton University Press (2nd Edition), 2018.
3. Linear System Theory and Design by Chen, Oxford University Press (4th Edition), 2013.

CP 330 (JAN) 2 : 1

Edge AI

This course provides students with the fundamentals of edge AI and hands-on experience in designing end-to-end AI systems for resource-constrained computing devices, such as microcontrollers It aims to equip students with knowledge of hardware systems and AI model optimization techniques and tools for IoT edge devices. After completing the course, students will have the skills to implement AI models, such as computer vision, on embedded/edge devices for various real-world applications, including smart cities, sustainability, healthcare, and agriculture. The topics to be covered in this course include: •Introduction to Edge AI •ML/AI Algorithms and Computer Vision Fundamentals •Edge AI Hardware and Accelerators •Edge AI Software Frameworks and Libraries •Model Optimization and Pruning Techniques and Tools •Deployment of Edge AI Systems and Case Studies

Pandarasamy Arjunan

Pre-requistes :

References : 1. AI at the Edge: Solving Real-World Problems with Embedded Machine Learning (2022) by Daniel Situnayake and Jenny Plunkett.
2. Deep Learning on Microcontrollers: Learn how to develop embedded AI applications using TinyML (2023) by Atul Krishna Gupta and Dr.

CP 321 (JAN) 2 : 1

Imitation Learning for Robotics

Course Content:
This course delves into the advanced field of imitation learning (IL) as applied to human-robot interaction, encompassing a diverse range of essential topics. It begins with an introduction to the application of machine learning for end users and the integration of IL within interaction pipelines, emphasizing the standardization of terminology to facilitate effective communication and development. Modalities such as reinforcements, preferences, and various teaching methods—absolute and relative—are explored alongside a survey of interfaces including physical contact, teleoperation, video, voice, display, sound, and haptics, highlighting their roles in enhancing interaction quality. Design considerations for IL algorithms encompass pivotal choices like access to reward functions (imitation versus reinforcement learning), system dynamics (model-based versus model-free approaches), and feature sets influencing learning outcomes, such as end-effector manipulation and object interaction. The course offers detailed study into IL techniques for both low-level motion trajectories and high-level task learning, covering trajectory representation methods (keyframe, DMP, probabilistic models, time-invariant dynamical systems) and strategies for generalizing learned behaviors to novel situations. It also addresses compliant control strategies crucial for safe human-robot collaboration, the role of simulators in robotics applications, and methodologies for conducting user studies and evaluating performance metrics. Throughout, students explore the current challenges and future opportunities in applying IL to enhance human-robot interaction across various domains.

Ravi Prakash

Pre-requistes :
This course assumes that the student has taken a basic course in AI and Robotics and is familiar with the following concepts:
References : 1. Celemin, Carlos, Rodrigo Pérez-Dattari, Eugenio Chisari, Giovanni Franzese, Leandro de Souza Rosa, Ravi Prakash, Zlatan Ajanović, Marta Ferraz, Abhinav Valada, and Jens Kober. "Interactive imitation learning in robotics: A survey." Foundations and Trends® in Robotics 10, no. 1-2 (2022): 1-197. 2. Takayuki Osa; Joni Pajarinen; Gerhard Neumann; J. Andrew Bagnell; Pieter Abbeel; Jan

CP 219 (AUG) 3 : 1

Machine Learning for Cyber-Physical and Mobility Systems

Data types (spatio-temporal data, event data, trajectories, time-series, point-reference etc.), data pre-processing (filtering, discretization, standardization, transformation, Imputation etc.), Regression (linear regression), Classification (logistic regression, Bayesian classification, SVM, Ensembles), Perceptron and ANN, Clustering (k-means, Spectral Clustering, GMM+EM, Hierarchical Clustering), Dimension Reductions (PCA, Manifold Learning MDS, t-SNE), Anomaly/Outlier Detection Techniques , Semi-supervised Learning, Active Learning

Punit Rathore

Pre-requistes :
Basic of Linear Algebra and Probability, Some programming experience

References : References
Pattern Recognition and Machine Learning, Christopher Bishop, New York, Springer, 2006
Learning from Data. Concepts, Theory, and Methods, by Vladimir Cherkassky, Filip Mulier, 2nd Edition, John Wiley and sons Inc., 2007.

Transportation and Urban Planning

Preface

SL 202 (JAN) 1 : 2

Capstone in Mobility Systems

This capstone course provides students with the opportunity to apply interdisciplinary knowledge to real-world problems in mobility systems. Working individually or in teams, students will identify, design, and implement a project that addresses a pressing challenge in sustainable, multimodal, or intelligent transportation. In the weekly lecture session, students will develop project management and communication skills, while deepening their technical understanding relevant to their individual or team projects.

Vijay Gopal Kovvali

Pre-requistes : None

References : Assigned reading material from instructor

SL 223 (JAN) 3 : 1

Transportation Safety and Injury Prevention Principles

Introduction to transportation basics; traffic safety as a public health hazard; DALYs; international crash data trends; India crash data trends; safe systems approach and vision zero; crash data analysis; proactive and reactive safety interventions; IRC codes and safety audits; vulnerable road users; heavy vehicle crash characteristics, crash modification factors and safety performance functions; methods of costing crashes; surrogate safety measures.

Vijay Gopal Kovvali

Pre-requistes :
• SL 221 Introduction to Multi-Modal Mobility Systems
• SL 222

References : • Relevant IRC codes.
• Rune, E., Hoye, A., Vaa, T., Sorensen, M. (2009) The Handbook of Road Safety Measures
• Tarko A.P. (2020). Measuring Road Safety with Surrogate Events

SL 221 (AUG) 3 : 1

Introduction to Multi-Modal Mobility Systems

Designing a transportation system; modes of transportation; characteristics of user, vehicle, and road; traffic engineering studies; geometric design principles; traffic analysis; transportation planning; transportation safety; fundamentals of traffic flow; traffic control basics; capacity and level of service; multi-scale modeling; sustainable transportation systems; public transit; freight transportation; multi-modal transportation; intelligent transportation systems; and smart cities.

Vijay Gopal Kovvali

Pre-requistes :
Basic analytical skills

References : • Garber, N.J. and Hoel, L.A. (2014). Traffic and Highway Engineering.
• Roess, R. P., Prassas, E. S., and McShane, W. R. (2019). Traffic Engineering.
• AASHTO (2011) A Policy on Geometric Design of Highways and Streets.

SL 222 (AUG) 3 : 1

Transportation Demand and Supply Modeling

Travel demand-supply interactions and equilibrium; Aggregate modelling methods for travel demand analysis (generation, spatial and temporal distribution, and modal split of travel); Statistical and econometric methods for transportation data analysis; Discrete choice models for travel behaviour analysis; Agent-based methods for travel demand analysis; Traffic assignment in transportation networks; Basics of Convex optimization; Shortest path algorithms; Wardrop user equilibrium; System optimum; Link-based algorithms and their implementation.

Abdul Rawoof Pinjari

Pre-requistes : None

References : (1) J. de D. Ortuzar and L.G. Willumsen, Modelling Transport (4th edition), John Wiley and Sons, 2011. (2) F. Koppelman and C.R. Bhat. A Self-Instructing Course in Mode Choice Modeling: Multinomial and Nested Logit Models, 2006. (3) Boyles, S. D., Lownes, N. E., & Unnikrishnan, A. (2020). Transportation network analysis. Vol. I: Static and Dynamic Traffic Assignment.

SL 224 (JAN) 3 : 1

Network Science and Optimization

Introduction to Networks; Shortest paths (Label setting and label correcting methods, A* algorithm, Contraction hierarchies); Max flows and Min cost problems (Augmenting path method, Cycle cancelling and successive shortest path methods); Spanning Trees; Time-dependent graphs; Random networks, Centrality measures (Small worlds, Power laws, Scale-free properties); Evolution of networks; Spreading phenomenon; Introduction to GNNs.

Tarun Rambha

Pre-requistes : None

References : Ahuja, R. K., Magnanti, T. L., & Orlin, J. B. (1988). Network flows. Pearson. Newman, M. (2018). Networks. Oxford University Press. Barabási, A. L. (2016). Network science. Cambridge University Press.

SL 225 (AUG) 3 : 1

Logistics and Freight Modeling

Introduction to freight and logistics systems; Introduction to mathematical modelling; Integer Programming; TSP and VRP; Matching and scheduling problems; Location problems; Heuristics; Collaborative logistics; Inventory modelling; Supply chains; Planning under Uncertainty; Revenue management; Freight movement analysis; Demand estimation and forecasting.

Tarun Rambha

Pre-requistes : Introductory course on optimization, which covers linear optimization and duality, such as CP 320 or equivalent.

References : Cachon, G., & Terwiesch, C. (2008). Matching supply with demand (Vol. 20012). New York: McGraw-Hill Publishing. Applegate, D. L. (2006). The traveling salesman problem: a computational study (Vol. 17). Princeton University Press. Wolsey, L. A. (2020). Integer programming. John Wiley & Sons.

SL 203 (JAN) 2 : 1

Introduction to Algorithms and Software Programming

Basics of programming; Data structures such as arrays, queues, stacks, trees, and maps; Analysis of algorithms; Searching and sorting; Greedy algorithms; Dynamic programming; Software development lifecycle; Software development methodologies (e.g., Agile, Waterfall); Scalable architecture design; Deployment practices and version control.

Tarun Rambha

Pre-requistes :
None

References : Sedgewick, R., & Wayne, K. (2011). Algorithms. Addison-Wesley Professional.
Cormen, T. H., Leiserson, C. E., Rivest, R. L., & Stein, C. (2022). Introduction to algorithms. MIT Press.
Kleppmann, M. (2017). Designing data-intensive applications: The big ideas behind reliable, scalable, and maintainable systems. " O'Reilly Media, In

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 maintains an Advanced Facility for Microscopy and Microanalysis (AFMM) and manages the Space Technology Cell (STC). The courses offered in different departments of the Division have been reorganized after review and revision. These are identified by the following codes.

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 letters of the course number indicate the departmental code. All the departments and centres (except the Space Technology Cell) of the Division provide facilities for research work leading to the degrees of MTech (Research) and PhD. There are specific requirements for completing a Research Training Programme (RTP) for students registered for research at the Institute. For individual requirements, students are advised to consult the Departmental Curriculum Committee (DCC). MTech Degree Programmes are offered in all the above departments except in the Centre for Product Design and Manufacturing, which offers Master of Design (MDes). Most of the courses are offered by the faculty members of the Division, but instruction by specialists in the field and experts from industries is arranged in certain topics. Student feedback is important to maintain quality, breadth, and depth in courses. Hence, students are urged to actively participate in providing feedback after the completion of each course. Written comments are especially encouraged from the students in addition to marking the scores.

Prof. G. K. Ananthasuresh

Dean

Division of Mechanical Sciences

Aerospace Engineering

Preface

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.

Rishita Das

Pre-requistes : None

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

AE 203 (AUG) 3 : 0

Mechanics and Thermodynamics of Propulsion

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

Sivakumar D

Pre-requistes : None

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

AE 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.

Radhakant Padhi

Pre-requistes : None

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, 1st edition, Prentice-Hall India.~Noureldin, A., Karamat, T. B.,and Georgy, J., Fundamentals of Inertial Navigation, Satellite-based Positioning and their Integration, 1st edition ,

AE 206 (AUG) 3 : 0

Hypersonic Flow Theory

Srisha Rao M V

Pre-requistes : None

References : None

AE 211 (AUG) 3 : 0

Mathematical Methods of Aerospace Engineers

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

Ramesh O N

Pre-requistes : None

References : Erwin Kreysig, Advanced Engineering Mathematics Wiley 2015.

AE 214 (JAN) 3 : 0

Turbulent Shear Flows

Ramesh O N

Pre-requistes : None

References : None

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.

Kartik Venkatraman , Srisha Rao M V

Pre-requistes : None

References : Houghton,E.L. and Carpenter,P.W.,Aerodynamics for Engineering Students, Butterworth-Heinemann 2003.~Katz, J. and Plotkin, A., Low-speed Aerodynamics,Cambridge, 2001.~Bertin, J.J. and Smith, M.L., Aerodynamics for Engineers,Prentice-Hall, 1989.

AE 222 (JAN) 3 : 0

Gas Dynamics

Fundamentals of thermodynamics, propagation of small disturbances in gases,normal and oblique shock relations, nozzle flows, one-dimensional unsteady flow, small disturbance theory of supersonic speeds, generation of supersonic flows in tunnels, supersonic flow diagnostics, supersonic flow over two-dimensional bodies, shock expansion analysis, method of characteristics, one-dimensional rarefaction and compression waves, flow in shock tube.

Joseph Mathew

Pre-requistes : None

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.

AE 225 (JAN) 3 : 0

Boundary Layer Theory

Discussions on Navier-Stokes equation and its exact solutions, boundary layer approximations, two-dimensional boundary layer equations, asymptotic theory,Blasius and Falkner Skan solutions, momentum integral methods, introduction to axisymmetric and three-dimensional boundary layers, compressible boundary layer equations, thermal boundary layers in presence of heat transfer, higher-order corrections to the boundary layer equations, flow separation -breakdown of the boundary layer approximation and the triple deck analysis, transitional and turbulent boundary layers - introduction and basic concepts.

Sourabh Suhas Diwan

Pre-requistes : None

References : Schlichting, H., Boundary Layer Theory, McGraw-Hill, 1968.~Rosenhead (ed.),Laminar Boundary Layers, Clarendon Press, 1962.~van Dyke, M., Perturbation Methods in Fluid Mechanics, Academic Press, 1964.~Recent Literature.

AE 229 (JAN) 3 : 0

Computational Gas Dynamics

Raghurama Rao S V

Pre-requistes : None

References : Laney, B., Computational Gas Dynamics.~Toro, E.F., Riemann Solvers and Numerical Methods for Fluid Dynamics.~Godlewski, E., and Raviart, P., Numerical Approximation of Hyperbolic System of Conservation Laws.

AE 241 (JAN) 3 : 0

Combustion

Thermodynamics of reacting systems. Chemical kinetics: equilibrium, analysis of simple reactions, steady-state and partial equilibrium approximations. Explosion theories; transport phenomena: molecular and convective transports. Conservation equations of multi-component, reacting systems. Premixed flames: Rankine-Hugoniot relations, theories of laminar premixed flame propagation,quenching and flammability limits. Diffusion flames: Burke-Schumann theory,laminar jet diffusion flame. Droplet combustion, turbulent combustion. Closure problem, premixed and nonpremixed turbulent combustion. Introduction to DNS and LES.

Irfan Ahmed Mulla

Pre-requistes : None

References : Turns, S.R., An Introduction to Combustion, McGraw-Hill, 2000.~Strehlow, R.A., Combustion Fundamentals, McGraw-Hill, 1985.~Kuo, K.K., Principles of Combustion, Wiley, 1986.~Law, C.K., Combustion Physics, Cambridge University Press, 2006.~Williams, F.A., Combustion Theory, 1985.

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.

Santosh Hemchandra

Pre-requistes : None

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 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.

Pratikash Prakash Panda

Pre-requistes : None

References : Combustion Physics by C. K. Law, Cambridge 2006.~Combustion Theory by F. A. Williams, Westview Press 1994.~Turbulent Combustion by N.Peters, Cambridge 2000.~Unsteady Combustor Physics by T. Lieuwen, Cambridge 2012.~Turbulent Flows by S. B. Pope, Cambridge, 2000.~Recent literature.

AE 252 (JAN) 3 : 0

Analysis and Design of Composite Structures

Introduction to composite materials, concepts of isotropy vs. anisotropy ,composite micromechanics (effective stiffness/strength predictions, load-transfer mechanisms), Classical Lamination Plate theory (CLPT), failure criteria, hygrothermal stresses, bending of composite plates, analysis of sandwich plates, buckling analysis of laminated composite plates, inter- laminar stresses, First Order Shear Deformation Theory (FSDT), delamination models, composite tailoring and design issues, statics and elastic stability of initially curved and twisted composite beams, design of laminates using carpet and AML plots, preliminary design of composite structures for aerospace and automotive applications. Overview of current research in composites.

Narayana Naik G

Pre-requistes : None

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

AE 258 (JAN) 3 : 0

Non - Destructive Testing and Evaluation

Fundamentals and basic concepts of NDT & E, Principles and applications of different NDE tools used for testing and evaluation of aerospace structures viz., ultrasonics, radiography, electromagnetic methods, acoustic emission,thermography. Detection and characterization of defects and damage in metallic and composite structural components.

M Ramachandra Bhat

Pre-requistes : None

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

AE 260 (JAN) 3 : 0

Modal Analysis: Theory and Applications

Introduction to modal testing and applications, Frequency Response Function (FRF) measurement, properties of FRF data for SDOF and MDOF systems, signal and system analysis, modal analysis of rotating structures; exciters, sensors application in modal parameter (natural frequency, damping and mode shape)estimation. Vibration standards for human and machines, calibration and sensitivity analysis in modal testing, modal parameter estimation methods,global modal analysis methods in time and frequency domain, derivation of mathematical models– modal model, response model and spatial models. Coupled and modified structure analysis. Application of modal analysis to practical structures and condition health monitoring.

Siddanagouda Kandagal

Pre-requistes : None

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 261 (AUG) 3 : 0

Structural Vibration Control

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. 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 PZ

Siddanagouda Kandagal

Pre-requistes : None

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. Nashif, D.N., Jones, D.I.G., and Henderson, J.P., Vibration damping, John Wiley, New York,

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.

Rajesh Chaunsali

Pre-requistes : None

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

Pre-requistes : None

References : Zarchan, P., Tactical and Strategic Missile Guidance, AIAA Publications, 4th Edition, 2002.~G.M. Siouris, Missile Guidance and Control Systems, Springer Verlag, 2004.~N.A.Sneyhdor, Missile Guidance and Pursuit, Ellis Horwood Publishers, 1998.

AE 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

Pre-requistes : None

References : S. Haykin, Neural Networks, Pearson Education, 2ed, 2001.

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.

Debiprosad Roy Mahapatra

Pre-requistes : None

References : None

AE 372 (AUG) 3 : 0

Applied optimal Control and State Estimation

Introduction and Motivation; Review of static optimization; Calculus of variations and Optimal control formulation; Numerical solution of Two- point boundary value problems: Shooting method, Gradient method and Quasi-linearization; Linear Quadratic Regulator (LQR) design: Riccati solution,Stability proof, Extensions of LQR, State Transition Matrix (STM) solution;State Dependent Riccati Equation (SDRE) design; Dynamic programming: HJB theory; Approximate dynamic programming and Adaptive Critic design; MPSP Design and Extensions; Optimal State Estimation: Kalman Filter, Extended Kalman Filter; Robust control design through optimal control and state estimation; Constrained optimal control systems: Pontryagin minimum principle,Control constrained problems, State constrained problems; Neighbouring extremals and Sufficiency conditions; Discrete Time Optimal Control: Generic formulation, Discrete LQR.

Radhakant Padhi , Ravi Prakash

Pre-requistes : None

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.,

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 differenceequations, 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.

Aravind Balan

Pre-requistes : None

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

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.

Pratikash Prakash Panda

Pre-requistes : None

References : None

AE 204A (AUG) 3 : 0

Mechanics of Flight Vehicle Structures

Solid mechanics: Vector and tensor algebra, kinematics of deformation, balance laws, constitutive equations; Torsion of circular, non-circular, and thin-walled cross-sections; Bending of thin-walled open and closed section beams, Flexural shear flow; Bending of thin plates, bending and twisting of thin plates; bending and in-plane loading of thin plates; Euler buckling of columns, flexure-torsion buckling of columns, buckling of thin plates; Flight vehicle materials; Structural components of flight vehicles and spacecraft; Loads on flight vehicles and V-N diagram.

Kartik Venkatraman , Vivekanand Dabade

Pre-requistes : None

References : Morton E. Gurtin. Introduction to Continuum Mechanics. Academic Press. 1981. P. Chadwick. Continuum Mechanics: Concise Theory and Practise. Dover Publications. 1999. T.H.G. Megson. Aircraft Structures for Engineering Students. Elsevier. 2022. David W.A. Rees. Mechanics of Solids and Structures. Imperial College Press. 2000.

AE 299A (JAN) 0 : 23

MTech 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 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

Pre-requistes : None

References : As prescribed by faculty.

AE 201A (JAN) 4 : 0

Flight and Space Mechanics

Flight Mechanics: Atmosphere, Essentials of Aerodynamics and Propulsion, Aircraft Performance, Static Stability, Equations of Motion- 3 DOF and 6 DOF, Attitude representation, Dynamic Stability Essentials, Flight Control Overview, Launch Vehicle Flight Essentials. Space Mechanics: Orbits in 2D and 3D, Orbital Manoeuvres, Docking, Interplanetary trajectories, Planetary Entry, Descent and Landing, Lagrange points and Halo Orbits, Orbital perturbations, Orbits in the Time Domain, Spacecraft attitude dynamics essentials.

Dinesh Kumar Harursampath

Pre-requistes : None

References : Introduction to Flight, John D Anderson. Aircraft Performance and Design, John D Anderson. Fundamentals of Airplane Flight Mechanics, David G Hull. Orbital Mechanics for Engineering Students, Howard D. Curtis.

Atmospheric and Oceanic Sciences

Preface

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 tropicaldynamics.Waves, jets and undercurrents on the equatorial beta plane. Waves and large-scale flow in the atmosphere and ocean from observations.

Jai Suhas Sukhatme

Pre-requistes : None

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 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

Pre-requistes : None

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,

AS 205 (JAN) 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.

P N Vinayachandran

Pre-requistes : None

References : Talley et al., Descriptive Physical Oceanography,6th Edition, 2011,B. Cushman- Roising, Introduction to GFD,Introduction to Physical Oceanography,http: /eanworld.tamu.edu (online book)

AS 207 (AUG) 3 : 0

Introduction to Atmospheric Dynamics

Jai Suhas Sukhatme

Pre-requistes : None

References : None

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

Pre-requistes : None

References : Papoulis, A., & U. Pillai, Probability, Random Variables andStochastic 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

AS 210 (JAN) 3 : 0

Numerical methods in atmospheric modeling

Equations used in atmosphere and climate modelling and their scale analysis; numerical discretization (horizontal, vertical, time-discretization) of governing equations (e.g., mass, momentum, energy conservation); solution of discretized equations; finite difference and finite volume schemes; overview of Semi-Lagrangian techniques; various spectral techniques and Galerkin projection; numerical solutions of example problems; modelling of sub-grid scale processes (e.g., cumulus parameterization); special topics (e.g., emerging techniques/architectures, analysis of data driven/hybrid approaches).

Ashwin K Seshadri

Pre-requistes : AS-207: Introduction to Atmospheric Dynamics

References : P H Lauritzen et al., Numerical Techniques for Global Atmospheric Models, Springer, 2011

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

Pre-requistes : None

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 216 (AUG) 3 : 0

Introduction to climate system

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

Govindasamy Bala

Pre-requistes : None

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

AS 313 (JAN) 3 : 0

Non-Linear Model in Climate Sciences

An introduction to nonlinear dynamics: linearization, bifurcation, chaos; Galerkin projection and model reduction; Derivation and analysis of low order models for the atmosphere, ocean, climate dynamics, and geophysics (e.g., Rayleigh-Bénard convection, vorticity, general circulation, ocean thermohaline circulation, planetary dynamos, energy balance and global warming, ice sheets, ENSO, carbon cycle, examples from paleoclimate); Special topics (data driven methods; dynamics on networks)

Ashwin K Seshadri

Pre-requistes : None

References : Primary references: A Provenzale and N Balmforth, Chaos and Structures in Geophysics and Astrophysics
H Dijkstra, Nonlinear Climate Dynamics
M Ghil and S Childress, Topics in Geophysical Fluid Dynamics: Atmospheric Dynamics, Dynamo Theory, and Climate Dynamics Course notes

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.

Bishakhdatta Gayen

Pre-requistes : None

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 217 (JAN) 2 : 1

Modelling and Forecasting

Syllabus Overview of Numerical Methods, Hierarchy of Models - global, regional, coupled models, Skill Score Metrics, Downscaling. Forecasting the weather, Ensemble Forecasting Technique, Dynamical Seasonal Prediction, Decadal Prediction and Climate Projections, Air Quality Modelling, Prediction of South Asian Monsoon. Architecture of Ocean Forecasting System Components, Numerical Ocean Models, Data Preparation, Forcing and IC, Data Assimilation, Forecast Evaluation. Introduction to PDE-constrained optimization, Linearization and Gradient Computation, Lagrange Multipliers; Adjoint-state Method, Seismic Wave Equation and Finite-difference Modeling, Full Waveform Inversion.

Arindam Chakraborty

Pre-requistes :
Atmosphere Dynamics/Ocean Dynamics/GFD

References : 1. ‘Implementing Operational Ocean Monitoring and Forecasting Systems’ https://www.mercator-ocean.eu/wp-content/uploads/2022/10/22-0 9-26-ETOOFS-BOOK-DOI-UPDATED-AB.pdf 2. Fundamentals of Atmospheric Modeling, Mark Z Jacobson, Cambridge University Press. 3. Numerical methods for Atmospheric and Oceanic Sciences, A. Chandrasekar,Cambridge University Press.

AS 298 (JAN) 0 : 18

MTech Project

This is a project course for the Joint MTech programme in Earth and Climate Sciences

Venugopal Vuruputur

Pre-requistes : None

References : Research Papers

Earth Sciences

Preface

ES 201 (JAN) 3 : 0

Introduction to Earth System

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

Pre-requistes : None

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 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

Pre-requistes : None

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

ES 202 (AUG) 3 : 0

Biogeochemistry

Prosenjit Ghosh

Pre-requistes : None

References : None

ES 203 (JAN) 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

Pre-requistes : None

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

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

Pre-requistes : None

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 207 (AUG) 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.

Ramananda Chakrabarti

Pre-requistes : None

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

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

Pre-requistes : None

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

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 ofthe 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 clim

Sambuddha Misra

Pre-requistes : None

References : Tracers in the Sea - Broecker and Peng, LDGEO Press, 1983~An Introduction to the Chemistry of the Sea - Michael E. Q. Pilson, Cambri dge University Press

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.

Sambuddha Misra

Pre-requistes : None

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

ES 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

Pre-requistes : None

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 218 (AUG) 3 : 0

Introduction to Seismology

This course is divided into three parts. It starts with an introduction to the dynamics of diverse seismic sources, e.g., volcanic, tectonic, glacial, fluvial, oceanic, atmospheric and artificial processes, which routinely shake the subsurface. The second part will present the following key topics in elastodynamics that guide the propagation of the waves originating from these seismic sources: types of elastic waves from a point dislocation sources; ray theory, travel-time function in layered media, turning points; plane waves in a homogenous medium and at interfaces; Snell’s law; Earth’s anisotropy; shear-wave splitting; seismic attenuation; surface-wave propagation and dispersion; free oscillations of the Earth. The final part connects the first two and introduces methods that not only help us infer the Earth’s structure but also study the source physics from the seismic measurements. Some motivating examples pertaining to the concepts discussed in this part include: 1. ground-moti

Pawan Bharadwaj Pisupati

Pre-requistes : None

References : Aki, Keiiti, and Paul G. Richards. Quantitative seismology. Chapman, Chris. Fundamentals of seismic wave propagation. Shearer, Peter M. Introduction to seismology.

ES 220 (AUG) 3 : 0

Introduction to satellite Geodesy

Short history of Geodesy: definition of Geodesy, First attempts at measuring Earth, developments in the 20th century, Modern Geodetictools Gravitation: Newtons law, potential theory, Laplace’s equation Solid Earth: visco-elastic Earth, Loading and deformations, Load love numbers, gravimetry Geodetic sensors in the orbit: GNSS,Altimeters, GRACE Climate change indicators and theirrelation to Geodesy: sea level rise, ice-sheet mass loss, polar motion.

Bramha Dutt Vishwakarma

Pre-requistes : None

References : 1.Heiskanen, W. A., and Moritz, H., “Physical Geodesy”, San Francisco, WH Freeman. 2.William, K. M., Theory of Satellite Geodesy: Applications of Satellites to Geodesy, Dover Earth Science. 3.Torge, W., Geodesy, De Gruyter Textbook.

ES 222 (JAN) 3 : 0

Data Analysis for Earth System Science

Linear regression, least squares inversion. Statistical Estimation theory and Bayesian methods. Fourier analysis, correlation, convolution. Principal component analysis, dimension reduction and random projections. Optimization algorithms: concept of gradient, Hessian, Jacobian. Unsupervised and supervised learning; deep neural networks for classification and regression. Time series Analysis: Auto-regressive models, AR, MA, ARMA models, Wiener’s theory of optimal prediction, estimation in dynamic models, case studies from earth atmospheric sciences.

Pawan Bharadwaj Pisupati

Pre-requistes : None

References : [1] A. Blum, J. Hopcroft, and R. Kannan (2020) Foundations of Data Sciences, Cambridge University Press [2] J. M. Lewis, S. Lakshmivarahan and S. K. Dhall (2006) Dynamic Data Assimilation: aleast squares approach, Cambridge University Press [3] Inverse Problem Theory, Albert Tarantola [4] Geophysical Signal Analysis, Enders A. Robinson, Sven Treitel

ES 225 (JAN) 1 : 0

Scientific writing and presentation

1. Basics of scientific writing 2. What to and do what not to do in science communication 4. Presenting your research work to engage and inspire

Bramha Dutt Vishwakarma

Pre-requistes : None

References : 1. "The Sense of Style" by Steven Pinker, ISBN: 978-0-241-95771- 2. "The elements of style", by W. Strunk and E.B. White, ISBN: 0-205-63264-5

Sustainable Technologies

Preface

ST 203 (JAN) 3 : 0

Design, Technology and Sustainability

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.

Monto Mani , Punit Singh

Pre-requistes : None

References : None

ST 206 (JAN) 2 : 1

Environmental and Natural Resources Management

Principles of environmental management, principles of ecology, environment and environmental management, policies and legal aspect of environmental management, overview of environmental impact assessment (EIA). Preparation and review of environmental impact assessment report, environmental audit, life cycle assessment as EM Tool. Environmental management systems standards: ISO 14000 (EMS). Related issues in environmental management, environmental design and environmental economics.

Ramachandra T V

Pre-requistes : None

References : Kulkarni, V., and Ramachandra, T.V., Environmental Management, Capital Publishers, New Delhi, 2006,Lo, C.P., and Yeung, A.K.W., Concepts and Techniques of GIS, Prentice Hall of India Private Limited, New Delhi, 2002,. Kanholm, J., EMS Manual, 21 Procedures and Forms, AQA Press, USA, 2000,Holling, C.S., Adaptive Environmental Assessment and Management, John Willey &

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 T V

Pre-requistes : None

References : Lillesand, T.M., and Kiefer, R.W., Remote Sensing and Image Interpretation, John Wiley & Sons, Inc., New York. Cambell,J.B., I ntroduction 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,

ST 214 (AUG) 3 : 0

Mathematical Analysis of Experimental Data

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

Lakshminarayana Rao M P

Pre-requistes : None

References : Douglas C. Montgomery, Design and Analysis of Experiments (2012), John Wiley and Sons, Inc.~Box, G. E. P., Hunter, W. G., and Hunter, J. S.(1978),Statistics for Experimenters: An Introduction to Design, Data Analysis, and Model Building, John Wiley & Sons. Inc. ISBN: 0-471 09315-7.

ST 213 (JAN) 3 : 0

Turbo machines in Renewable Energy

The objectives of the course is to refine turbo machinery designs in challenging operating conditions imposed by renewable energy sources characterized by variability(input/outputsides)and low intensity/enthalpy levels.concepts include Euler theory,velocity traingles,dimensional analysis, meanline/streamline theory,loss models,performance estimation,Cordier/nsds diagrams and others.Practical design approach from theory and experimental modules for incompressible fluids(hydro turbines, wind turbines,and liquid pumps)and compressible fluids (air,steam,and new working fluids for solar thermal and waste heat sources)Radial,diagonal and axial flow turbo machines with impulse and reaction physics.Discussion on innovative and unconventional turbo machines.

Punit Singh

Pre-requistes : None

References : DixonS.L and HallC.A, Fluid Mechanics and Thermo Dynamics of Turbomachinery, 6th Edition,Elsevier,publication 2010,~Neschleba M, Hydraulic turbines-Their design and equipment , Atria Prage,1957,~StepanoffA.J,Centrifugal and Axial Flow Pumps,JohnWiley & Sons,Inc.,1957,~Horlock J.H,Axial Flow Compressors and Axial Flow Turbines,Fluid Mechanics and

ST 217 (AUG) 3 : 1

Field hydrology, river engineering and basin studies

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, macroeco

Punit Singh

Pre-requistes : None

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

ST 219 (AUG) 3 : 0

Separation Technologies for Sustainable Industrial Processes

Consider any product that you use from the time you wake up till the end of the day - plastics, paper, pharmaceuticals, soaps and detergents, textiles, and many more. In this course, we focus on an important set of steps in the manufacture of such items that are critical in our daily lives, namely the 'chemical separation' steps. Such chemical separations typically account for 40-70% of the total cost of the complete manufacture process of the item. Cumulatively, separations in various industries add up to 15% of the world's energy requirements. However, chemical separations and the concerned separation technologies are responsible for several important processes, such as extracting the final product from the synthesis medium; treating effluent streams before environmental discharge; recovering materials that can be reused for subsequent manufacture cycles; or isolating valuable intermediate products that can be used in a different industry, or sold. A few examples of chemical separat

Yagnaseni Roy

Pre-requistes : None

References : [1] De Haan, André B., and Hans Bosch, 'Industrial separation processes: fundamentals. Walter de Gruyter, 2013'. [2] Seader, J., E.Henley, and D. Roper 3rd. "Separation Process Principles, ISBN:9781118139622." [3] Chapters 7-9 from 'Chemical Engineering Design - Principles, Practice and Economics of Plant and Process Design' by Gavin Towler and Ray Sinnot,' Second edition.

ST 218 (JAN) 3 : 0

Sustainable Wastewater Management

This course has been designed to provide its participants knowledge on the fundamentals and practices in wastewater management in both urban and rural contexts. Starting with (i) characteristics of different wastewaters and necessity for their treatment; the course will delve into: (ii) principles of conventional activated sludge process, challenges and sustainability issues; (iii) alternative treatment methods & recent developments with concerns over energy efficiency, nutrient removal/recovery and/or footprint; (iv) need, bottlenecks and options for advanced wastewater treatment and water recycling; and(v alternative sanitation concepts with emphasis on rural communities. In addition to understanding the fundamentals of different treatment options for wastewater, the participants will learn to see wastewater as a resource and appreciate sustainable practices. The course will be conducted using a combination of interactive lecture & exercise sessions, problem-based learning approach, field visit, and presentation of case studies. Wastewater origin, composition & hazards: parameters and their measurement; domestic wastewater streams; industrial wastewater; stormwater; municipal wastewater and volume flows; agricultural runoff; water & environmental pollution; ecotoxicological impacts; health hazards; water scarcity. Conventional wastewater treatment: centralised vs. decentralised approach; treatment objectives; mechanical treatment; biological treatment; nutrient removal; microbial metabolism & kinetics; introduction to activated sludge model no. 1; wastewater disinfection; sludge treatment & management; energy demands; challenges and sustainability issues. Alternatives to conventional activated sludge process: anaerobic wastewater treatment; energy recovery; membrane bioreactor; biofilm reactors; hybrid technologies; advanced biological nutrient removal; aerobic granular sludge; nutrient recovery; microalgae. Water recycling: micropollutants; environmental concern; water reuse; activated carbon adsorption; ozonation; advanced oxidation processes; membrane technologies. Alternative sanitation approaches: sanitation challenges; low-cost solutions; decentralised treatment; ecological(resource oriented) sanitation; source separation; nutrient recovery; lagooning; anaerobic digestion; terra preta sanitation; composting; greywater treatment; constructed wetlands.

Sreenivasan Ramaswami

Pre-requistes : None

References : Wastewater engineering: Treatment and reuse, 4th edition. Editors: George Tchobanoglous; Franklin L. Burton; H. David Stensel. Publisher: McGraw-Hill. Biological Wastewater Treatment: Principles, Modelling & Design, 2nd edition. Editors: Guang-Hao Chen; Mark C.M. van Loosdrecht; G.A. Ekama; Damir Brdjanovic. Publisher: IWA Publishing.

ST 221 (AUG) 3 : 0

Concrete Technology: fundamentals and sustainable practices

This module aims to provide students with fundamental knowledge in the area of cement hydration, sustainable mineral admixtures and chemical admixtures, and their influence on fresh and hardened stage of cement-based materials. It also provides students with in-depth knowledge in concrete durability, mechanical properties and time- dependent deformations. The module discusses the basic considerations and design philosophy for performance-based design and production of sustainable concrete. The students will also learn about the progress in concrete technology and the latest development in high-strength, high-performance concrete, lightweight concrete, and self-healing concrete. Sustainable development in construction industry including application of recycled aggregates, bio-based admixtures and low-carbon concrete would be discussed as well. The module would be taught through interactive lecture sessions, exercises, problem-based learning approach and site visits.

Souradeep Gupta

Pre-requistes : None

References : 1. Concrete, by David Darwin, J. Francis Young, and Sidney Mindess. Publisher: Pearson. 2. Properties of concrete, 5th edition, by A.M. Neville. Publisher: Pearson.

ST 223 (JAN) 3 : 0

Green Catalysis in Chemical Industries

This module aims to provide a basic understanding of the green chemistry approach to the catalytic processes of industrial importance. This subject is discussed with a consideration of surface chemistry, modern techniques for studying surfaces, and the study of important organic and inorganic solid catalysts, including the rapidly growing area of shape-selective, single-atom catalysis, etc. Topics will focus on some of the most important and growing areas of catalysis, including biomass conversion, waste recovery, and CO2 capture and utilization.

The module would be taught through interactive lecture sessions, exercises, and problem-based learning approaches.

Navneet Kumar Gupta

Pre-requistes :

None

References : P. Anastas and N. Eghbali Green Chemistry: Principles and Practice, Chem. Soc. Rev., 2010, 39, 301-312. W. D. Jong, J. R. V. Ommen Biomass as a Sustainable Energy Source for the Future: Fundamentals of Conversion Processes, Wiley, 2014 (ISBN:9781118304914).

ST 231 (JAN) 1 : 0

Seminar

As per instructors and prospective guide's advice

Punit Singh

Pre-requistes : None

References : Peer reviewed journals

ST 232 (JAN) 0 : 30

Project

As per interest and guide's interaction

Punit Singh

Pre-requistes : None

References : Peer reviewed journal and reference books

ST 226 (AUG) 3 : 0

Sustainable Water Management

Water cycle, renewable water. Freshwater resources: surface water, ground water. Water usage, stress & scarcity. Water smart agriculture. Rainwater harvesting. Surface, ground & rainwater quality. Contamination scenarios & need for treatment. Drinking water treatment & requirements. Other remediation techniques. Industrial water treatment & requirements. Seawater desalination. Wastewater quantity & quality, parameters. Water pollution, hazards & need for wastewater treatment. Conventional wastewater treatment. Resource recovery options. Recycling of treated wastewater. Options for industrial wastewater treatment.

Sreenivasan Ramaswami

Pre-requistes : None

References : Wastewater engineering: Treatment and reuse, 4th edi?on.Editors: George Tchobanoglous; Franklin L. Burton; H. David Stensel. Publisher: McGraw-Hill. Separa?onProcess Principles, 3rd edi?onErnest J. Henley, J. D. Seader, D. Keith Roper. Publisher: Wiley. Lecture notes and slides

ST 229 (JAN) 3 : 0

Low-carbon infrastructure

This module aims to provide students with the state-of-the-art knowledge in areas of low-carbon buildings and infrastructure including the effect of climate change, maintainability, energy efficiency, indoor air quality, implication on health and wellness. This module would involve interactive lectures and assignments. The course covers topics such as Climate change and building design, “Green” building concepts, Indoor air quality and wellness, Sustainable construction and maintainability and Low-carbon materials and processes Evaluation: 60% (assignments/quiz), 40% final exam

Souradeep Gupta

Pre-requistes : None

References : i. Compressed Earth block and rammed earth structures by B.V. Venkatarama Reddy ii. Concrete by David Darwin, J. Francis Young, and Sidney Mindess iii. ASHRAE Indoor air quality guide – best practices for design, construction and commissioning (ASHRAE Indoor Air Quality Guide) iv. Maintainability of Facilities. 2nd Edition by Yit Lin Chew v. A handbook on developing sustainable

ST 228 (JAN) 3 : 0

Data Analysis, Machine Learning and Artificial Int

This course is designed for graduate students in data analysis, machine learning, and AI. It covers data collection and analysis, integrating physics and mathematics. Students will learn essential concepts, techniques, and tools for data processing, prediction, and AI-driven problem-solving. Hands-on projects and real-world examples will help participants develop practical skills for applying data analysis and machine learning in various domains

Lakshminarayana Rao M P

Pre-requistes : None

References : Wolfgang Ertel, Introduc?onto Ar?ficialIntelligence John Paul Mueller, Machine Learning for Dummies Douglas C. Montgomery, Design and Analysis of Experiments (2012), John Wiley and Sons, Inc. Ernest O Doebelin, Engineering Experimenta?on, McGraw-Hill Interna?onalG. Beckwith and Lewis. N. Buck, Mechanical measurements, Box, G. E. P., Hunter, W. G., and Hunter, J. S.

ST 227 (JAN) 2 : 1

Environmental Analytical Chemistry

Introduction to environmental/water laboratory: fundamental instruments, lab water types and grades of chemicals. Solutions: concentration, dilution factor, preparing solutions. Water quality parameters: pH, electrical conductivity, turbidity & dissolved oxygen. Solids in water: total, suspended, dissolved. Hardness and alkalinity. Spectrophotometric determination: principle, limits, determination of ammonium-nitrogen, phosphate-phosphorous. Nitrogen in water – determination of nitrogen compounds (N-NH4+, N-NO2-, N-NO3- and TN) and material balance. Organic parameters: COD, BOD, TOC. Chromatographic techniques, determination of anions by ion chromatography. Different wastewater sources, water & environmental pollution.

Sreenivasan Ramaswami

Pre-requistes : None

References : APHA, Standard methods for the examina?onof water and wastewater. American Public Health Associa?on,23rd edi?on, Washington DC, (2017). ISO standards.

ST 225 (AUG) 3 : 0

Sustainable Materials

The "Sustainable Materials" course offers a comprehensive understanding of key materials, emphasizing their environmental impact and sustainable practices. It explores eco-friendly material creation using renewable resources, starting with the need for sustainable materials and the environmental issues with current materials. The course covers renewable resources like lignocellulosic biomass, plastic waste, and CO2, teaching various conversion and synthesis techniques (biological, chemical, thermal, etc.). Students will learn about the properties and industrial applications of sustainable materials, including carbonaceous materials (graphene, nanotubes, etc.), polymers (new class and dropins), fuel components, surfactants, pharmaceuticals, etc. The aim is to teach students the skills to develop and apply sustainable materials for a greener future.

Navneet Kumar Gupta

Pre-requistes : None

References : V. Popa and I. Volf Biomass as Renewable Raw Material to Obtain Bioproducts of High-Tech Value, Elsevier B.V., 2018. htps://doi.org/10.1016/C2015-0-05810-5

ST 224 (AUG) 3 : 0

Renewable energy

Renewable energy holds promise for a cleaner future. This module will explore various renewable energy sources such as solar, wind, geothermal, wave, thermo-chemical, and bio-chemical methods, with a specific emphasis on technological advancements. Special attention will be given to the production of hydrogen and high-energy molecules through thermo-chemical conversion. Additionally, it will cover biomass and municipal solid waste (MSW) as significant carbon/hydrogen resources, examining their transformation into valuable chemicals and fuels using innovative processes such as pyrolysis, gasification, and thermo/bio-chemical conversion. By integrating emerging chemocatalytic methods, these advancements aim to improve energy generation with sustainable alternatives that minimize waste and carbon emissions.

Lakshminarayana Rao M P , Navneet Kumar Gupta

Pre-requistes : None

References : M. Kanoglu, Y. A. Cengel, J. M. Cimbala Fundamentals and Applications of Renewable Energy 2019 McGraw-Hill Education ISBN: 978-1260455304 W. D. Jong, J. R. V. Ommen Biomass as a Sustainable Energy Source for the Future: Fundamentals of Conversion Processes American Institute of Chemical Engineers, Inc. 2014 DOI:10.1002/9781118916643. G. W. Huber, S. Iborra, A. Corma Chem.

ST 233 (JAN) 3 : 0

Thermal-fluids engineering for practical applications

Dimensional analysis, Navier-Stokes equations, viscous flow, major and minor losses in pipes, boundary layers, lift and drag, heat transfer and fluid dynamics studies of laminar and turbulent flows, forced and natural convection, heat exchangers (LMTD and epsilon-NTU methods), heat transfer in boiling and condensation, analysis of steady flow components of thermodynamic plants as well as thermodynamic cycles such as the Rankine cycle and Otto cycle.

Yagnaseni Roy

Pre-requistes :
None, but students with a background in heat transfer, fluid mechanics, or thermodynamics would find the course easier to follow.

References : [1] “An Integrated approach to Thermodynamics, Fluid Mechanics, and Heat Transfer, Part II”, by Ernest Cravalho, Joseph L. Smith Jr., John Brisson II, Gareth H. McKinley, published by Oxford University Press.
[2] A Heat Transfer Textbook (4th Edition) by J.H. Lienhard IV and J. H. Lienhard V.

Chemical Engineering

Preface

CH 201 (AUG) 3 : 0

Engineering Mathematics

Linear algebraic equations, linear operators, vector and function spaces,metric and normed spaces, existence and uniqueness of solutions. Eigen values and eigen vectors/functions. Similarity transformations, Jordan forms,application to linear ODEs, Sturm-Liouville problems. PDE's and their classification, initial and boundary value problems, separation of variables,similarity solutions. Series solutions of linear ODEs. Elemetary perturbation theory. References:

Prabhu R Nott , Ananth Govind Rajan

Pre-requistes : None

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

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

Pre-requistes : None

References : Gupta S.K., Numerical Methods for Engineers, New Age International Publishers,3rd edition, 2015~Chapra, S.C. and Canale, R.P., Numerical Methods for Engineers, McGraw Hill, NY, 6th edition, 2010~Beers, K.J., Numerical Methods for Chemical Engineering, Cambridge Univ. Press, Cambridge, UK 2010

CH 203 (AUG) 3 : 0

Transport Processes

Dimensional analysis and empirical correlations. Molecular origins of diffusion. Steady/unsteady shell balances in one/two dimensions. Solution of unsteady diffusion equation by similarity transform and separation of variables. Conservation laws and constitutive relations in three dimensions. Diffusion dominated transport. Fluid flow due to pressure gradients. Boundary layer theory for transport in forced convection. Natural convection.References:

Kumaran V , Ananth Govind Rajan

Pre-requistes : None

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 Neelakantan Punnathanam

Pre-requistes : None

References : Tester,J. W.,and Modell, M., Thermodynamics and its Applications

CH 205 (JAN) 3 : 0

Chemical Reaction Engineering

Course Outline Overview of Chemical Reaction Engineering The Attainable Region Theory Analysis of Multiple Reactions -- Chemical Reaction Stoichiometry, Concepts in Catalysis and Microkinetic Modeling Design of Ideal Reactors - Unsteady State, Energy Balance Non-Ideal Reactor Analysis Multiphase Reactor DesignCFD for Reactive Flows.

Venugopal S

Pre-requistes : None

References : •Ming, D., Glasser, D., Hildebrandt, D., Glasser, B., and Metzger, M., http://attainableregions.com/ – 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 ChemicalEngineering • Fogler.,http://umich.edu/~elements/5e/index.html

CH 206 (AUG) 1 : 0

Seminar Course

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

Rahul Roy

Pre-requistes : None

References : None

CH 207 (JAN) 1 : 0

Applied statistics and design of experiments

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

Venugopal S

Pre-requistes : None

References : Overview of statistics; Bayesian Inference applied to solve Chemical Reaction Engineering Problems

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

Pre-requistes : None

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 242 (AUG) 3 : 0

Special Topics in Theoretical Biology

Motivation for theoretical studies of biological phenomena; Epidemiology, spatio-temporal disease spread, vaccination and other interventions; Population dynamics, predator-prey systems, microbiomes; Viral dynamics, within-host models, HIV, SARS-CoV-2; Drug pharmacokinetics and therapy, compartmental models; Molecular evolution and phylogenetics, antimicrobial resistance; Biological networks, cell signalling and fate decisions; Immune responses, innate and adaptive responses, vaccination and other immunomodulation strategies; Cancer and aging; Examples will illustrate deterministic, stochastic, and data-driven modeling approaches

Narendra M Dixit

Pre-requistes : None

References : 1. J. D. Murray, Mathematical biology I & II, Springer, 2003 (3rd edition)
2. K. Raman, An introduction to computational systems biology, CRC, 2021
3. U. Alon, An introduction to systems biology, CRC, 2020

CH 247 (JAN) 3 : 0

Introduction to Molecular Simulation

Introduction to molecular dynamics; conservation laws; integration schemes: verlet, velocity verlet, leapfrog; constraint dynamics; extended Lagrangian dynamics; thermostats and barostats; introduction to Monte Carlo techniques; Metropolis algorithm; NVT, NPT and GCMC simulations; estimation of pressure, chemical potential, radial distribution function, Ewald summation; introduction to density functional theory (DFT); exchange-correlation functionals, basis sets, pseudopotentials, k-point sampling; Hubbard-corrected DFT, hybrid DFT, and dispersion corrections.

Sudeep Neelakantan Punnathanam , Anand Srivastava

Pre-requistes : None

References : 1.M. P. Allen and D. J. Tildesley, Computer simulation of Liquids, Oxford University Press, New York, 1987 2.D. Frenkel and B. Smit, Understanding Molecular Simulation: From Algorithms to Applications, 2nd Ed., Academic Press, San Diego, 2002 3.D. S. Sholl and J. A. Steckel, Density Functional Theory: A Practical Introduction, John Wiley & Sons, Inc., 2009 4.F. Jensen, Introduction to

CH 248 (JAN) 3 : 0

Molecular Systems Biology

Various topics highlighting experimental techniques and modeling approaches in systems biology for problems ranging from molecular level to the multi- cellular level will be covered. Topics: Properties of biomolecules,Biomolecular Forces, Single molecule experimental techniques, Molecular motors, Molecular heterogeneity, Self- organization, Enzyme kinetics, Modeling cellular reactions and processes, Fluctuations and noise in biology, Cellular variability, Biological networks, Modeling dynamics of bioprocesses and cellular signaling.

Rahul Roy

Pre-requistes : None

References : Philip Nelson, Biological Physics: Energy, Information, Life, W. H. Freeman,2007~Edda Klipp, Wolfram Liebermeister, Christoph Wierling, Axel Kowald, HansLehrach, Ralf Herwig, Systems Biology, Wiley-Vch, 2009~Uri Alon, An Introduction to Systems Biology: Design Principles of Biological Circuits,Chapman & Hall/CRC Mathematical & Computational Biology, 2006.

CH 299 (JAN) 0 : 32

Dissertation Project

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

Ananth Govind Rajan

Pre-requistes : None

References : None

CH 235 (JAN) 3 : 0

Modeling in Chemical Enginereing

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

Sanjeev Kumar Gupta

Pre-requistes : None

References : Lecture notes

CH 250 (JAN) 3 : 0

Laminar flows

Vectors and tensors, vector calculus, kinematics, rate of deformation tensor, conservation equation, viscous flows,potential flows, boundary layer theory, vorticity dynamics.

Kumaran V

Pre-requistes : CH203 Transport Processes, OR basic courses in applied mathematics linear algebra, vector calculus) and fluid mechanics. CH203 Transport Processes, OR basic courses in applied mathematics linear algebra, vector calculus) and fluid mechanics.

References : Batchelor, G. K., An introduction to fluid dynamics,Cambridge University Press, 1967. Panton, R. A.,Incompressible Flow,Wiley Interscience, 1984.

CH 254 (JAN) 3 : 0

Heterogeneous Catalysis for Environmental Remediation

Overview of inorganic and organic contaminants in water, permissible limits and effects; introduction to primary, secondary and tertiary water treatment processes; fundamentals of heterogeneous catalysis; steps of catalytic reactions: rate-determining steps and rate equations, effectiveness factors; overview of advanced oxidation process; homogeneous and heterogenous Fenton processes: photocatalysis, piezo-catalysis, photothermal catalysis, electro-Fenton process; design, preparation, characterization and modulation of heterogeneous catalysts; degradation and transformation of contaminants; effects of various parameters on catalytic contaminant removal; scalability and practical applications of heterogeneous catalysts.

Debashis Roy

Pre-requistes : None

References : 1. Fogler, S, H., Elements of Chemical Reaction Engineering, 4th ed., Pearson Education, 2006.
2. Chorkendorff, I., and Niemantsverdriet, J, W., Concepts of Modern Catalysis and Kinetics, 3rd ed., John Wiley and Sons, 2017.
3. Thomas, J, M., and Thomas, W, J., Principles and Practice of Heterogeneous Catalysis, 2nd ed., John Wiley and Sons, 2014.

CH 255 (AUG) 3 : 0

Introduction to Polymer Science

Introduction: polymer microstructure, types of polymers, molar mass distribution and measurement; Ideal chain: flexibility mechanism, conformation of an ideal chain, ideal chain model, radius of gyration, distribution of end-to-end vector, scaling argument, pair correlation of ideal chain; Real polymer chain: excluded volume and self-avoiding walk, effect of solvent, deforming real and ideal chain, temperature effect on real chain, adsorption of a single chain, distribution of end-to-end distance for real chain; Thermodynamics of mixing: energy and entropy, equilibrium and stability, mixture at low composition, quality of solvent, osmotic pressure, semidilute theta solutions; Random branching without gelation: concepts and definition of gelation, mean field model of gelation, scaling model of gelation; Computer simulation in polymer physics: molecular dynamics, Monte Carlo, random and self-avoiding walk.

Nirmalya Bachhar

Pre-requistes : None

References : 1) Polymer Physics by Michael Rubinstein & Ralph H Colby, Oxford University Press
2) Introduction to Polymer Physics by M Doi & H See, Oxford University Press
3) Polymer Solutions by Iwao Teraoka, John Wiley & Sons

Civil Engineering

Preface

CE 247 (AUG) 3 : 0

Remote Sensing and GIS for Water Resources Engineering

Basic concepts of remote sensing. Airborne and space borne sensors. Digital image processing. Geographic Information System. Applications to rainfall - runoff modeling. Watershed management. Irrigation management. Vegetation monitoring. Drought and flood monitoring, Environment and ecology.Introduction to digital elevation modeling and Global Positioning System (GPS). Use of relevant software for remote sensing and GIS applications.

Nagesh Kumar D

Pre-requistes : None

References :
Remote Sensing and Image Interpretation, T.M. Lillesand and R.W. Kiefer, John Wiley & Sons, 2000.~Remote Sensing - Principles and Interpretation,

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, Introductionto stresses and deformation measures; Mohr-Coulomb failure criteria, soil laboratory tests; Critical state and stress paths. Shear Strength and Stiffness of Sands; Consolidation, shear strength and stiffness of clays

Tejas Gorur Murthy

Pre-requistes : None

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

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.

Tejas Gorur Murthy

Pre-requistes : None

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

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.

Srinivas V V

Pre-requistes : None

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

CE 204 (AUG) 3 : 0

Solid Mechanics

Introduction to tensor algebra and calculus, indicial notation, matrices of tensor components, change of basis formulae, eigenvalues, Divergence theorem. Elementary measures of strain. Lagrangian and Eulerian description of deformation. Deformation gradient, Polar decomposition theorem, Cauchy-Green and Lagrangian strain tensors. Deformation of lines, areas and volumes. Infinitesimal strains. Infinitesimal strain- displacement relations in cylindrical and spherical coordinates. Compatibility. Tractions, body forces,stress at a point, Cauchy's theorem. Piola-Kirchhoff stress tensors. Momentum balance. Symmetry of the Cauchy stress tensor. St. Venant's Principle. Virtual Work. Green's solids, elastic strain energy, generalized Hooke's Law, material symmetry, isotropic linear elasticity in Cartesian, cylindrical and spherical coordinates, elastic moduli, plane stress, plane strain,. Navier's formulation. Airy stress functions. Selected problems in elasticity. Kirchhoff's uniqueness theor

Ananth Ramaswamy

Pre-requistes : None

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

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.

Narayan K Sundaram

Pre-requistes : None

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 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

Pre-requistes : None

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.

Keshav Bharadwaj Ravi

Pre-requistes : None

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.

J M Chandra Kishen

Pre-requistes : None

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 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 transformation

J M Chandra Kishen , Debraj Ghosh

Pre-requistes : None

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 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

Pre-requistes : None

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 probabilitydistributions 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 - autocorrelation and spectral density functions. Applications to hydrologic forecasting.

Rajarshi Das Bhowmik

Pre-requistes : None

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. andTang, 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 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 Pallepati

Pre-requistes : None

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

Pre-requistes : None

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

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.

P Anbazhagan

Pre-requistes : None

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 c losure; 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 foryielding; 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

Pre-requistes : None

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.

CE 228N (AUG) 3 : 0

Introduction to the Theory of Plasticity

The uniaxial tensile test & Bauschinger effect; Dislocations and the physical basis of plasticity; slip; dislocation mechanics, stress field and energy of a Volterra dislocation; 1D network models of plasticity and overstress viscoplasticity; structure of phenomenological plasticity theories; internal variables; yield criteria (Tresca, von Mises, Mohr-Coulomb, Drucker-Prager); geometry of yield surfaces; Levy Mises equations; flow rules; plastic/ viscoplastic potentials; consistency condition; elastoplastic tangent modulus; isotropic and kinematic hardening; back-stress tensor; Drucker's postulate; Principle of maximum plastic dissipation; associativity; POMPD as a nonlinear optimization problem; convexity; normality; uniqueness; selected elastic-plastic boundary value problems (tension and torsion of tubes and rods, pressurized thin and thick spherical shells); collapse; unloading and residual stresses; advanced hardening models; introduction to computational plasticity; integration of plasticity models; return mapping; principle of virtual work; overview of finite elements for plasticity; overview of topics in advanced plasticity.

Narayan K Sundaram

Pre-requisites :
None, but a background grad-level solid mechanics course (CE 204 or ME 242) is strongly recommended.
References : Plasticity Theory - J. Lubliner
Plasticity for Engineers - C. R. Calladine
Theory of Plasticity - J. Chakrabarty

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 ased 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

Pre-requisites : None

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

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

Pre-requisites : None

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 236 (AUG) 3 : 0

Fracture Mechanics

Introduction; Linear Elastic Fracture Mechanics; Design based on LEFM; Elasto-Plastic Fracture Mechanics; Mixed Mode Crack Propagation; Fatigue CrackPropagation; Finite Elements in Fracture Mechanics.

Remalli Vidya Sagar

Pre-requistes : None

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 240 (JAN) 3 : 0

Uncertainty Modeling and Analysis

Deterministic vs nondeterministic perspectives. Sources of uncertainty. Epistemic vs. aleatoric uncertainty. Data driven vs. physics driven uncertainty modelling. Different approaches such as probabilistic, interval, fuzzy. Introductory probability and statistics, point estimation, hypothesis testing, time series. Modelling: connecting data to the probabilistic models. Discretization of random fields. Tools for uncertainty propagation. Computational aspects of uncertainty propagation.

Debraj Ghosh

Pre-requistes : None

References : None

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

Pre-requistes : None

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

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

Pre-requistes : Modeling Transport and Traffic course, exposure to UG courses of Transportation Engineering from B-Tech (Civil Engg.)

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 263 (AUG) 3 : 0

Modelling Transport and Traffic

Ashish Verma

Pre-requistes : None

References : None

CE 274 (AUG) 3 : 0

Earthquake Resistant Design

Concept of sustainability and its relevance to urban transport; Introduction to Sustainable Transport; Indicators of Sustainable Transport; modelling and analytical techniques to measure and analyze sustainability of transportation projects and policies; Urban and Land use planning for Sustainable Transport; Modelling and Planning for Public transport, and Non-Motorized Transport; impact of factors related to perception/aspirations, travel behaviour, on development and promotion of sustainable transport.

J M Chandra Kishen

Pre-requistes : None

References : Gudmundsson H; Hall RP; Marsden G; Zietsman J (2015) Sustainable Transportation Indicators, Frameworks, and Performance Management,

CE 277 (JAN) 3 : 0

Remote Sensing in Ecohydrology

Introduction to ecohydrology, fundamentals of exchange ofenergyand 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.

Debsunder Dutta

Pre-requistes : None

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.

Swetha Veeraraghavan

Pre-requistes : None

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 299 (JAN) 0 : 22

Project

The project work is aimed at training the students to analyze independently problems in geotechnical engineering, water resources en gineering, 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

Pre-requistes : None

References : None

CE 213 (JAN) 3 : 0

Systems Techniques in Water Resources Engineering

Optimization Techniques - constrained and unconstrained optimization, Kuhn-Tucker conditions, Linear Programming (LP), Dynamic Programming (DP), Multi-objective optimization, applications in water resources, water allocation,reservoir sizing, multipurpose reservoir operation for hydropower, flood control and irrigation. Review of probability theory, stochastic optimization.Chance constrained LP, stochastic DP. Surface water quality control.Simulation - reliability, resiliency and vulnerability of water resources systems.

Nagesh Kumar D

Pre-requistes : None

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 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.

Debsunder Dutta

Pre-requistes : None

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

CE 271 (JAN) 3 : 0

Choice Modeling

Individual choice theories; Binary choice models; Unordered multinomial choice models (multinomial logit and multinomial probit); Ordered response models (ordered logit, ordered probit, generalized ordered response; rank-ordered data models); Maximum likelihood estimation; Sampling based estimation (choice-based samples and sampling of alternatives); Multivariate extreme value models (nested logit, cross- nested logit); Mixture models (mixed logit and latent class models); Mixed multinomial probit; Integrated choice and latent variable models; Discrete-continuous choice models with corner solutions; Alternative estimation methods (EM, analytic approximations, simulation); Applications to travel demand analysis.

Abdul Rawoof Pinjari

Pre-requistes : None

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 260 (AUG) 3 : 0

Rock Mechanics

Physical, mechanical and engineering properties of rocks; rock discontinuities; strike; dip; bedding planes; joints; faults; folds; unconformities; geological exploration by bore holes; methods of drilling; rock strength and rock mass strength; rock failure criteria; rock mass classification; rock mass rating, geophysical methods; geology of dam sites and reservoirs; Importance of geology in dam construction; rock slope stability Stresses and strains; theory of elasticity; in-situ stresses; numerical and computer methods in rock mechanics and under-ground excavations.

Jyant Kumar , Swetha Veeraraghavan

Pre-requistes : None

References : 1. Engineering Rock Mechanics. John A. Hudson and John P. Harrison. 2.Fundamentals of Rock Mechanics. John Jaeger, N. G. Cook, and Robert Zimmerman. 3. Introduction to Rock Mechanics. Goodman, R.E. John Wiley & Sons. 4. Rock Mechanics and Rock Engineering. Ömer Aydan.

CE 295 (JAN) 3 : 0

Earth Retaining Structures and Earthen Dams

Earth retaining structures, lateral earth pressure coefficients, Rankine and Coulomb theories, passive earth pressure computation with curved rupture surfaces, stability of gravity and cantilever retaining walls, stability of vertical cuts, braced excavations, cantilever and anchored sheet piles, stability of infinite slopes and finite slopes, different methods of slices for the analysis of finite slopes and embankments, stability analysis of earth and rock dams, forces/loads to be considered, different load cases, factors of safety in different conditions, filters for earthen dams, seepage analysis.

Jyant Kumar

Pre-requistes : None

References : 1. Terzaghi, K., Theoretical Soil Mechanics, John Wiley,1965.Taylor, D.W., Fundamentals of Soil Mechanics, John Wiley,1948. 2. Bowles,J.W., Analysis and Design of Foundations, 4th and 5th Ed., McGraw-Hill, 1988 & 1996. 3. Lambe, T.W. and Whitman, R.V., Soil Mechanics, Wiley Eastern Limited, 1976. 4. Earth and earth-rock dams: Engineering problems of design and

CE 285 (JAN) 3 : 0

Disaster Management for Dams

Overview of disaster management and flood mapping, Flood risk associated with various types of dams, Dam hazard classification systems, Dam failure modes and assessment of consequences, Dam breach modelling, Hydrologic, Hydraulic and breach outflow routing, Remote Sensing and Geographic Information Systems (GIS) applications for emergency preparedness and flood mapping, Dam hazard classification framework in India, Emergency action plans preparation and implementation.

Nagesh Kumar D , Srinivas V V

Pre-requistes : None

References : 1.Guidelines for Developing Emergency Action Plans for Dams, Dam Safety Rehabilitation Directorate (DSRD), Central Water Commission (CWC), 2016. 2.Guidelines for Mapping Flood Risks Associated with Dams, DSRD, CWC, 2018. Heywood, I., Cornelius, S., and Carver, S. 3.An Introduction to Geographical Information Systems, Pearson Education, 1998. Lillesand T.M. and Kiefer

CE 202A (JAN) 2 : 1

Integrated Investigation of Dams

Introductions to Geotechnical field investigations, laboratory experiments and relevant IS codes; Geotechnical and Geophysical investigation of Dams; Theory and demonstration of Ground Penetrating Radar testing: Multichannel Analysis of Surface Testing: Seismic borehole tests, Down/Up and Cross hole testing; Electric Resistivity testing; Planning of Integrated Investigation. Field experimental case studies of Dam investigations.

Raghuveer Rao Pallepati , P Anbazhagan

Pre-requistes : None

References : An-Bin Huang, Paul W Mayne, Geotechnical and Geophysical Site Characterization, CRC Press, 2008. Head, K.H., Manual of Soil Laboratory Testing. Vols. 1 to 3, 1981. Compendium of Indian Standards on Soil Engineering Parts 1 and II, 1987 - 1988.

CE 201A (AUG) 3 : 0

Dam safety surveillance, instrumentation and monitoring

Dam safety inspection program; Inspecting embankment dams, concrete and masonry dams; Inspecting spillways, outlets and mechanical equipment; Instrumentation and monitoring; Instrumentation types and their uses; Hydro-meteorological instrumentation; Instrumentation data collection and management; Monitoring data organization and analysis.

J M Chandra Kishen , Debsunder Dutta

Pre-requistes : None

References : 1) Guidelines for safety inspection of dams (2018), Central water Commission, Govt. of India, New Delhi. 2)Guidelines for instrumentation of Large dams (2018), Central water commission, Govt. of India, New Delhi.

CE 207A (AUG) 3 : 0

Characterization of Bituminous Materials

Introduction and overview of mixture design; chemical, physical, and rheological properties of asphalt binder; behavior, testing, and selection of aggregates; design of asphalt mixtures, compaction and properties; common distresses and characterization of distresses; additives and surface properties; engineered materials, warm mixtures, RAP, and other special mixtures.

Satyavati Komaragiri

Pre-requistes :

None

References : 1) F.L. Roberts, P. S. Kandhal, E.R. Brown, D-Y. Lee and T. W. Kennedy, 2nd Edition, NAPA Research and Education Foundation, 19
2) Dallas N. Little, David H. Allen, and Amit Bhasin. Modeling and design of flexible pavements and materials, Springer, 2018.
3) C. E. G. Justo, S.K. Khanna, and A. Veeraragavan, Highway engineering, Nem Chand & Bros, 2017.

CE 209A (AUG) 3 : 0

Elastic Wave Propagation and Applications in NDE

Introduction to elastic wave propagation and its role in Nondestructive evaluations. 1D nondispersive wave propagation, 1D dispersive wave propagation, introduction to Spectral Finite Element Method (SFEM). Two-dimensional scalar wave propagation (acoustic waves): scalar waves in free field, material interface, analysis of layered system using dynamic stiffness method, introduction to lamb waves (SH waves), love waves, cylindrical and spherical waves. Elastic wave propagation: Elastodynamic formulation, Helmholtz decomposition, elastic wave on a plane, P waves, SV waves, Rayleigh waves, and guided waves in layered media. NDE applications, Practical aspects of implementation including instrumentation, signal processing and interpretation of results.

Vivek Samu

Pre-requisites : None

References : 1. Wave propagation in Elastic Solids, J.D. Achenbach (1973). 2.Ultrasonic Guided Waves in Solid Media, J.L. Rose, Cambridge University Press, 2014. 3. Wave Propagation in Structures, James F. Doyle, Second Edition, Springer, 1997.

CE 210A (AUG) 3 : 0

Thermodynamic Modelling of Cementitious Systems

A brief recap of cement chemistry, cement hydration and concrete technology (influence of binder chemistry on reaction products, concrete microstructure, mineral and chemical admixtures, microstructure and pore structure; concrete mechanics and durability); A brief recap of thermodynamics (zeroth law, first law, second law, activity); Law of mass action; Mass Balance calculations; Determination of Reactivity; Fundamentals of thermodynamic modelling; Predicting reaction products; Predicting pore solution compositions; Predicting pore volumes; Kinetic modelling; Structure-property relations in concrete.

Keshav Bharadwaj Ravi

Pre-requisites :
Prerequisites: The participants are expected to have basic knowledge of cement hydration and concrete durability. Undergraduate level

References : 1. “Concrete: Microstructure, Properties, and Materials” by P.K. Mehta and Paulo J. M. Monteiro, 4th Edition (2014), McGraw Hill Education (India), New Delhi, India. 2. “Introduction to the Thermodynamics of Materials” by David R. Gaskell and David E. Laughlin, 6th Edition (2018), CRC Press, Boca Raton, FL, USA 3. Online tutorials 4. Recent literature

CE 211A (JAN) 3 : 0

Concrete Durability and Repair

Introduction to concrete; Concrete constituents and manufacture; Introduction to cement and concrete microstructure; Transport through cement microstructure - physics and measurement; Dimensional Changes in Concrete - shrinkage and creep; Corrosion of steel and repair, role of chlorides; Carbonation; Aggregates and durability of concrete; Freeze-thaw and salt-scaling; Sulphate attack and delayed ettringite formation, physical salt attack; Effect of fire, acid attack, abrasion and cavitation; Concrete quality control, workmanship and choice of materials; Biological processes and mic; Non-destructive and laboratory test-methods; Inspection, repair and protection of structures; Durability based design of structures.

Keshav Bharadwaj Ravi

Pre-requisites :
Undergraduate level courses on Concrete Technology and Civil Engineering Materials are recommended.

References : I will be combining information from several books in this course and will also include information from recent literature. Reference Books: 1. Mehta P.K. and Monteiro P.J.M., Concrete Microstructure Properties and Materials, Fourth Edition, Tata McGraw Hill, 2014 2.Newman J. and Choo B.S., Advanced Concrete Technology - Testing and Quality, Elsevier, 2003 3. Neville A.M., Properties of

CE 204B (JAN) 2 : 0

Pavement Engineering

Introduction to pavement engineering; design of flexible and rigid pavements: selection of pavement design input parameters, traffic loading and volume, material characterization, drainage, failure criteria; pavement design of overlays; pavement performance evaluation; non-destructive tests for pavement; IRC, AASHTO design codes; maintenance and rehabilitation of pavements.

Satyavati Komaragiri

Pre-requistes :
None

References : 1) Rajib B Mallick and Tahar El-Korchi, Pavement Engineering, Principles and Practice, CRC Press, 2009.
2) Y.H. Huang, Pavement Analysis and Design, Prentice-Hall, New Jersey, 1993.
3) E. J. Yoder, M. W. Witczak, Principles of Pavement Design, Wiley New York, 1975.

Climate Change

Preface

Materials Engineering

Preface

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.

Abinandanan T A

Pre-requistes : None

References : None

MT 202 (AUG) 3 : 0

Thermodynamics and Kinetics

Classical and statistical thermodynamics, Interstitial and substitutionalsolid 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

Pre-requistes : None

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 andorientation 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

Pre-requistes : None

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.

MT 208 (JAN) 3 : 0

Diffusion in Solids

Aloke Paul

Pre-requistes : None

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 209 (JAN) 3 : 0

Defects in Materials

Review of defect classification and concept of defect equilibrium. Review of point defects in metallic, ionic and covalent crystals. Dislocation theory - continuum and atomistic. Dislocations in different lattices. Role of anisotropy. Dislocation kinetics. Interface thermodynamics and structure.Overview of grain boundaries, interphase boundaries, stacking faults and special boundaries. Interface kinetics: migration and sliding. Defect interactions: point defect-dislocation interaction, dislocation-interface interactions, segregation, etc.. Overview of methods for studying defects including computational techniques

Karthikeyan Subramanian

Pre-requistes : None

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-

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.

Bhagwati Prasad

Pre-requistes : None

References : R. E. Hummel, Electronic Properties of Materials,S. O. Kasap, Principles of Electronic Materials and Devices,S. M. Sze, Semiconductor devices: Physics andTechnology,D. Jiles, Introduction to the electronic properties of materials

MT 218 (JAN) 3 : 0

Modeling and Simulation in Materials Engineering

Importance of modeling and simulation in Materials Engineering. nd numerical approaches. Numerical solution of ODEs and PDEs, explicit and implicit methods, Concept of diffusion, phase field technique, modelling of diffusive coupled phase transformations, spinodal decomposition. Level Set methods, Celula Automata,: simple models for simulating microstructure,. Finite element modelling,: Examples in 1D, variational approach, interpolation functions for simple geometries, (rectangular and triangular elements); Atomistic modelling techniques,: Molecular and Monte-Carlo Methods.

Abhik N Choudhury

Pre-requistes : None

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,

MT 220 (AUG) 3 : 0

Microstructural Engineering of Structural Materials

Review of crystal defects: dislocation theory, grain boundaries and heterophase boundaries, defect kinetics and defect interactions; Role of microstructure on mechanical properties: strengthening mechanisms, ductilizing mechanisms, toughening mechanisms, effect of microstructure on creep, fatigue and impact resistance; Methods of controlling microstructures: phase transformations (L?S, V?S, S? S), heat treatments, solidification, mechanical processing, texture control, recovery and recrystallization, sintering, etc;Case studies of microstructural control of engineering metals, alloys and ceramics (Ni- base superalloys, YSZ, ceramic-matric composites, Ti-alloys,steels, etc)

Surendra Kumar Makineni , Ankur Chauhan

Pre-requistes : None

References : None

MT 231 (AUG) 3 : 0

Interfacial Phenomena in Materials Processing

Ashok M Raichur

Pre-requistes : None

References : None

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.

Praveen Ramamurthy , Rajeev Ranjan , Chandan Srivastava , Praveen Kumar , Suryasarathi Bose , Abhik N Choudhury , Ankur Chauhan , Sachin R Rondiya , Pikee Priya

Pre-requistes : None

References : None

MT 243 (JAN) 0 : 2

Laboratory Experiments in Metallurgy

Chandan Srivastava

Pre-requistes : None

References : None

MT 245 (AUG) 3 : 0

Transpoert processes in Process Metallurgy

Govind S Gupta

Pre-requistes : None

References : None

MT 250 (AUG) 3 : 0

Introduction to Materials Science and Engineering

Subodh Kumar

Pre-requistes : None

References : None

MT 253 (AUG) 3 : 0

Mechanical Behaviour of Materials

Theory of Elasticity. Theory of Plasticity. Review of elementary dislocationtheory. 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

Pre-requistes : None

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

MT 261 (AUG) 3 : 0

Organic Electronics

Fundamentals of polymers. Device and materials physics. Polymer electronicsmaterials, 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 Ramamurthy

Pre-requistes : None

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

MT 271 (AUG) 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

Pre-requistes : None

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

MT 299 (JAN) 0 : 32

Dissertation Project

The M.E. Project is aimed at training the students to analyse independently any problem posed to them. The project may be a purely a nalytical 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.

Govind S Gupta , Chandan Srivastava

Pre-requistes : None

References : None

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

Pre-requistes : None

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

MT 240 (AUG) 3 : 0

Principles of Electrochemistry and Corrosion

Introduction to electrochemical systems, including batteries, fuel cells and capacitors. Designing electrochemical systems with emphasis on thermodynamics, kinetic, and mass transport limitations. Measuring electrochemical properties with various measurement techniques. Basic electrochemical principles governing corrosion. Types and mechanisms of corrosion. Advances in corrosion engineering and control.

Naga Phani B Aetukuri , Sai Gautam Gopalakrishnan

Pre-requistes : Basic knowledge in materials thermodynamics

References : 1. A.J. Bard and L.R. Faulkner, Electrochemical Methods: Fundamentals and Application, 2nd Edition, Wiley India 2006. ISBN:812650
2. M.G. Fontana, Corrosion Engineering, 3rd Edition, McGraw-Hill, N.Y., 1978.

MT 211 (AUG) 3 : 0

Magnetism, Magnetic Materials, and Devices

Fundamentals: Classical and quantum mechanical pictures of magnetism; spin orbit coupling, crystal field environments, diamagnetism, paramagnetism, ferromagnetism, antiferromagnetism, dipolar and exchange interactions, magnetic domains, magnetic anisotropy, magnetostriction, superparamagnetism, biomagnetism, and spin glass Bulk magnetic Materials: Transition and rare earth metals and alloys. Oxide based magnetic materials. Hard, soft and magnetostrictive materials, Magnetic shape memory alloys, Structure-microstructure-magnetic property correlations. Low dimensional Magnetic systems and devices: Magnetic nanostructures, thin films, and epitaxial heterostructures; exchange bias and exchange coupling, and magneto-optical materials and devices, AMR, GMR, TMR, spin-transfer torque, spin-orbit torque and spin-Hall effect; Multiferroics, magnetoelectric and magnetoionics; nonvolatile magnetic memory, synaptic and neuromorphic computing devices; Experimental techniques: VSM, SQUID, Mossbauer, MFM, Magneto-transport, Magnetooptical Kerr-effect, XMLD and XMCD

Bhagwati Prasad

Pre-requistes : None

References : S. O. Kasap, Principles of Electronic Materials and Devices; Stephen Blundell, Magnetism in Condensed Matter; J.M.D. Coey, Magnetism and Magnetic Materials; B. D. Cullity and C.D. Graham, Introduction to Magnetic Materials; K. M. Krishnan, Fundamental and Application of Magnetic Material

MT 217 (AUG) 3 : 0

Computational Mathematics for Materials Engineers

Vector and tensor algebra; Basics of linear algebra and matrix inversion methods; Coordinate transformations methods; Optimization methods, Probability and statistics; Numerical methods: Concepts of discretization in space/time, implicit, explicit; Solution to ODEs(Euler, Heun, Runge-Kutta methods), PDEs (Elliptic, Parabolic, Hyperbolic), solutions to Laplace equation and applications, transient diffusion and wave equation; Discretization methods (FDM, FVM, FEM); iterative solution schemes Jacobi, Gauss-Seidel, ADI, Multigrid, Fourier-spectral schemes; Root finding methods, interpolation, curve-fitting, regression; Special functions: Bessel, Legendre, Fourier, Laguerre, etc; Computational tools for the solution to all the above problems will be discussed along with canonical examples from materials problems. Software tools, based on python and/or MATLAB, will also be introduced in the course. Instructor: A N Choudhury and S. Gautam G

Abhik N Choudhury , Pikee Priya

Pre-requistes : None

References : Books: Advanced Engineering Mathematics; Erwin Kreyzig Mathematical physics (V. Balakrishnan) Numerical methods for Engineers(Steven C. Chapra and Paymond P. Canale) Numerical Recipes in C(William H. Press, Vetterling, Teutolsky, Flannery)

MT 309 (JAN) 3 : 0

Introduction to Manufacturing Science

• Introduction to casting processes: Mechanism of solidification, Gravity die casting; Pressure assisted casting processes: Pressure die casting, Squeeze casting etc.; Compocasting; Semi-solid casting processes: Rheocasting, Thixocasting, Rheo and Thixo-moulding etc.; Centrifugal casting; Vacuum assisted casting. (6 hrs) • Introduction to metal forming processes: Mechanics of metal working, friction, temperature and strain rate effects, processing maps. Forging, Rolling, Extrusion, Wire and tube drawing, Hot and Cold Working, Rolls and Roll Pass Design, Extrusion Processes, Extrusion Defects ,Experimental methods to assess formability of sheet materials, Defects in sheet metal forming. (18 hrs) • Introduction to Welding processes: Insight of weld metallurgy; Weld mechanics, Filler and base material interaction; Quality control of weld; Weld & HAZ microstructure; Effects of process parameters on weld quality in welding processes.

Prosenjit Das

Pre-requistes : None

References : Rao, P.N., Manufacturing Technology Volume 1 (Foundry, Forming and Welding), McGraw Hill Education (India) Pvt. Ltd. Rao, P.N.,Manufacturing Technology Volume 2 (Metal Cutting and Machine Tools), McGraw Hill Education (India) Pvt. Ltd. Ghosh, A., Malik, A.K., Manufacturing Science, East-West Press Pvt. Ltd. Khanna, O.P.,Foundry Technology, Dhanpat Rai Publications. Dieter,

MT 307 (JAN) 3 : 0

Materials in Extreme environments

Overview of engineering systems under extreme environment Background review: Materials response under low and high temperature: Microstructure and atomic structure, defects, Materials response under quasistatic loadings (tensile, fracture and fatigue), strengthening mechanisms, Effect of temperature on microstructure and properties, Creep, high-temperature fatigue Materials response under mechanical extremes: Loading states, Elastic waves in solids, Shock loading, Distance-time diagrams, Static high-pressure devices, Platforms for loading at intermediate strain rates, Platforms for shock and quasi-isentropic loading, Shock compression of FCC, BCC and HCP metals, Amorphous metals, Phase transformations, Plasticity in compression, Ramp loading, Release, Spallation and Failure, Adiabatic shear, Response of Ceramics Materials response under Irradiation: Irradiation basics, Irradiation-Processes Leading to Extreme Situations, Irradiation Using Different Incident Beams, Defect Dynamics in Materials Under Irradiation, Irradiation-Enhanced Diffusion, Irradiation-Induced Segregation, Radiation-Induced/Enhanced Phase Transformation, Influence of Radiation-induced Microstructure on Mechanical Properties Materials in Hostile corrosive environment: Introduction, Corrosion by Liquid Sodium, Materials for the Hostile Corrosive Environments in Steam Water Environments, Materials in Seawater Environment

Ankur Chauhan

Pre-requistes : None

References : George Dieter, Mechanical Metallurgy; Neil Bourne, Materials response under mechanical extreme; Gary was, Fundamentals of Radiation Materials Science

MT 205 (JAN) 3 : 0

Structural characterization of Materials

(A) Diffraction
Fourier transforms, Reciprocal lattice, Ewald construction, Kinematical and dynamical theory of diffraction, Howie-Whelan relations, , neutron and electron diffraction, Kikuchi patterns, X-Ray Diffraction (XRD), Basics of x-rays, generation, Experimental methods in x-ray diffraction (Laue, Oscillation/rotation, powder diffraction) and applications

(B) Imaging
Interaction volume, Concepts of resolution, magnification and depth of field, Electron optics, Lenses and lens aberrations
1. Light Microscopy (LM)
Working principle of an optical microscope, Modes of contrast, applications
2. Scanning electron microscopy (SEM)
Working principle of an SEM, Imaging modes, Electron Back Scattered Diffraction, applications
3. Transmission electron microscopy (TEM)
Working principle of a TEM, Modes of operation, Imaging using diffraction contrast, phase contrast and Z-contrast, applications
4. Scanning probe microscopy (SPM)
Different types of SPMs, Working principle of an Atomic Force Microscope (AFM), Modes of operation, Applications

(C) Spectroscopy:
XPS, Raman, FTIR (working principle) and their applications.

(D) Field Ion Microscopy (FIM) and 3D-atomprobe tomography (3DAPT)
Working principle of FIM and 3DAPT and their applications.

Rajeev Ranjan , Chandan Srivastava , Surendra Kumar Makineni

Pre-requistes : None

References : 1.C Barry Carter and David Williams, Transmission Electron Microscopy 2.James Howe, Transmission Electron Microscopy and Diffractometry of Materials 3.Baptiste Gault, Atom Probe Microscopy 4.B. D.Cullity, X-ray Diffraction

MT 204 (AUG) 3 : 0

Structure and Properties of Materials

Bonding and crystal structures Bonding in solids, Cohesive energy for ionic and van der Waals solids, simple crystal structures of compounds, metals and alloys. Geometrical crystallography Crystal symmetry and Bravais Lattices, Stereographic projection, Point groups, Space groups, Description of crystal structures with space group. Tensor properties of crystals, Neumann's principle and related concepts. Heckmann diagram and multifunctionality, Thermodynamics of equilibrium properties of crystals. Point Defects Types of point defects, Equilibrium point defect concentration, Defect chemistry, Effects on diffusion, ionic conductivity, electronic and optical properties Line Defects Continuum and atomistic models, stress fields and energy of dislocations, forces on dislocations, dislocation motion and slip, dislocations in FCC, BCC and HCP metals, Effects on mechanical properties and phase transformations Planar Defects Types of interfaces: heterophase interfaces (S-V, S-L, S S) and homophase interfaces (grain boundaries and stacking faults), Interface thermodynamics and Gibbs-Thompson effect, Anisotropy of interface energy, Effect of interfaces on properties including mechanical behavior, phase transformations, magnetic, optical, etc.

Karthikeyan Subramanian , Rajeev Ranjan

Pre-requistes : This is a foundational course which aims to introduce basics of crystallography, defects and properties. It is meant for Masters, UG (4th Sem) and PhD students.

References : • Structure of Materials, M. D. Graef and M. E. Henry, Cambridge 2007 • Fundamentals of Ceramics, M. W. Barsoum, IOP publishsing Ltd. 2003 • Physical Properties of Crystals, J. F. Nye, Oxford University Press, 2006 • Richard J D Tilley, Defects in Solids, Wiley 2008 • P.G.Shewmon: Diffusion in Solids, 2nd ed., TMS, 1989 • D. Hull and D. J.Bacon: Introduction to dislocations, 4th ed.,

MT 273 (AUG) 3 : 0

Semiconductor Films: Deposition and Spectroscopic Characterization

MT 273 (AUG) 3:0 Semiconductor Films: Deposition and Spectroscopic Characterization This course focuses on the imparting fundamental understanding of the working principles of advanced high vacuum deposition techniques used for the fabrication of semiconductor thin films and devices. The necessary theoretical background, important mechanisms associated with growth of films, and the working principles of various optical spectroscopic techniques will be covered. Semiconductor fundamentals: Common semiconducting materials and their crystal structures; Intrinsic and extrinsic point defects in semiconductors; Electronic band structure; Defect states and their influence on semiconducting properties. Thin film growth processes: Nucleation and growth mechanisms; uncorrelated or random deposition; surface diffusion-controlled growth; ballistic deposition; shadowing effects, etc. Thin film deposition techniques: Hot-wire chemical vapor deposition (HW CVD); plasma-enhanced chemical vapor deposition (PE-CVD); atomic layer deposition (ALD); pulse laser deposition (PLD); RF sputtering, physical vapor deposition (PVD); DC sputtering; Molecular Beam Epitaxy (MBE); thermal evaporation; etc. Spectroscopic characterization of semiconductors: Ultraviolet-visible- near infrared spectroscopy (UV-Vis-NIR); photoluminescence spectroscopy (PL); time-resolved photoluminescence spectroscopy (TRPL); transient spectroscopy (TAS); etc. Hands-on laboratory sessions: Hands-on laboratory sessions and practical demonstrations will be conducted for a few high vacuum deposition techniques and spectroscopic measurements for a few semiconductors’ thin films

Sachin R Rondiya

Pre-requistes : None

References : References 1. Thin Film Deposition: Principles and Practice by Donald L. Smith 2. Spectroscopic Methods in Organic Chemistry by Dudley H. Williams and Ian Fleming 3. Principles of Instrumental Analysis by Douglas A. Skoog, F. James Holler, and Stanley R. Crouch 4. Introduction to Spectroscopy by Donald L. Pavia, Gary M. Lampman, George S. Kriz, and James R. Vyvyan 5. Handbook of

MT 303 (JAN) 2 : 1

Materials Informatics

The course will be structured into three modules, with learnings from one module transferred into others. Each module will have lecture sessions followed by hands-on/tutorial sessions where students have to learn new tools and execute them, via jupyter-notebooks (or similar) frameworks. Module 1 will focus on basic aspects of computations and machine learning. Module 2 will work on statistical mechanics, lattice models, and coarse graining techniques commonly used. Module 3 will describe the construction and validation of machine-learned interatomic potentials, and other advanced machine learning topics relevant for materials science.

Sai Gautam Gopalakrishnan , Ankur Chauhan , Prosenjit Das

Pre-requistes : Students should have preferably taken the “MT 202: Thermodynamics and Kinetics of Materials” and “MT 217: Computational Mathematics for Materials Engineers” courses. Students should preferably have a laptop where they can install necessary libraries/codes and execute them.
References : There are no text books for this course. Suggested are some books for additional reading. •“Computational Materials Science”, June Gunn Lee, Second Edition 2016 •“Understanding molecular simulation: from algorithms to Applications”, Daan Frenkel and Berend Smit, Second Edition, 2002 •“Electronic structure: basic theory and practical methods”, Richard M. Martin, Second Edition, 2020

MT 227 (JAN) 2 : 1

Introduction to Crystal Mechanics and Plasticity

Overview of crystallography, unit cells, miller indices, types of dislocations, dislocation motion, slip systems, Elastic deformation review, plasticity (yield point, plastic flow, hardening), Yield criteria, Single crystal plasticity (slip systems, critical resolved shear stress), Polycrystalline microstructure (heterogeneity, texture, stretch and rigid body rotation), Schmid rule, strain from slip, Dislocation dynamics (slip by dislocation glide, thermally activated climb), self and latent hardening, Statistically stored and geometrically necessary dislocations, Constitutive equations, flow rules, hardening laws, rate dependence, strain gradient plasticity, Finite element crystal plasticity case study and demonstration of using multi-technique experiments to develop and validate crystal plasticity models, Limitations of crystal plasticity and introduction to Multiscale simulations, Demonstration of Molecular Dynamics and dislocation dynamics simulations. Python based IDE will be used to carry out lab work and project work.

Response to Comments:
MT205 is a course on Structural Characterization of Materials using diffraction, microscopy, and spectroscopy techniques. The proposed course, however, will focus on plasticity at the mesoscale and its computational modeling. While experimental results, such as observations from SEM and TEM, may be referred to for demonstrating the predictive capability of the numerical modeling techniques, prior knowledge of interpreting such microscopy images is not a prerequisite. Students who have taken MT205 may find their familiarity with these techniques beneficial, but any required explanation will be thoroughly provided during the course.
MT206 is a course on Texture and Grain Boundary Engineering, which introduces the concepts of orientation, material processing stages, and the influence of texture and grain boundaries on the mechanical and physical properties of materials. Unlike the proposed course, MT206 does not include a computational component. Students who have taken MT206 may find their understanding of orientation-dependence helpful in appreciating how crystal plasticity modeling accounts for orientation while simulating deformation behavior. However, this prior knowledge is not necessary, as the proposed course will sufficiently introduce the concept of crystal orientation and its relevance to crystal plasticity.
MT209 introduces Defects in Materials, including various types of defects, dislocations, the kinetics of dislocation motion, and computational techniques such as first-principles calculations (DFT) for studying defects. The proposed course is distinct in that it focuses on the impact of defects and dislocations on deformation behavior, exploring how these effects can be modeled at the mesoscale using crystal plasticity. Students who have taken MT209 may benefit from a foundational understanding of dislocations, including their density and types, which are critical parameters in crystal

Praveen Kumar , Suchandrima Das

Pre-requistes : None

References : Introduction to Computational Plasticity by Fionn Dunne and Nik Petrinic
Theory of Dislocations by Hirth and Lothe

MT 310 (AUG) 3 : 0

Manufacturing Process modelling

Introduction to numerical methods (working principle, merits-demerits and applications): FDM, FVM, BEM, FEM, Die filling analysis (nature of flow, back pressure, porosity, air entrapment), Solidification (behavior and filling time), Transport phenomena during solidification: governing equations, phase change, Finite Volume based multiphase and multiscale model of solidification, Initial and boundary conditions, Phase field model of solidification microstructure formation and defect generation, Analytical method and Boundary Element Method to solve the heat conduction equation applied to welding processes, Finite Volume/ Finite Element based multiphase flow model of melt pool transport phenomena and solidification in fusion welding process, Thermo mechanical modeling of the residual stress in welding, Transport phenomena involved in Metal/Ceramic Injection Moulding processes: estimation of filling and cooling time, injection pressure, defect visualization etc., Finite element based continuum model of sintering densification and mechanical behaviour, Molecular dynamics based model of neck growth, microstructure evolution, Finite volume method for modeling additive manufacturing: - melting/ solidification and mass-transfer, Microstructure modelling of multi-layer and multi-track additive manufacturing processes, Forming limit diagrams, FE analysis of deformation behaviour of metals, Finite Element Analysis (FEA) for Metal Forming Processes (forging, rolling, drawing and shearing) and its comparison with the analytical techniques, Analytical and FE modelling of orthogonal machining, FE modelling of chip formation and prediction of cutting forces/machinability of Light alloys and composites

Prosenjit Das

Pre-requistes : Introduction to Manufacturing Science MT 309

References : 1. Computational Fluid Dynamics: The Basics with Applications by J.D.Anderson
2. Goldak, J. A., Akhlaghi, M. (2005). Computational welding mechanics. Germany: Springer.
3. Fundamentals of Powder Metallurgy by W.D. Jones

MT 312 (AUG) 3 : 0

Polymer Engineering and Sustainable Materials

Polymer Science and Engineering Fundamentals
Introduction to polymers, 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.
Nanocomposites and Interface Engineering
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.
Processing and Properties
Various processing techniques like solution mixing, melt processing. Unique properties of blends, composites/nanocomposites in rheological, mechanical, and physical properties and applications.
Sustainable Polymers: Recycling, Circular Economy, and Advanced Materials
polymer lifecycle, its environmental impact, and the shift from a linear to a circular economy, emphasizing principles like reduce, reuse, and recycle. We'll explore mechanical and chemical recycling technologies, including advanced methods like depolymerization and pyrolysis, alongside strategies for design for recyclability. A significant segment focuses on vitrimers, examining their unique chemistry, synthesis, processing, and role in creating self-healing and highly recyclable materials. bioplastics and compostable plastics.

Suryasarathi Bose

Pre-requistes : None

References : 1. "Principles of Polymerization" by George Odian
2. "Introduction to Polymer Science and Technology" by R.J. Young and P.A. Lovell
3. "Polymer Blends and Composites" by L.A. Utracki

MT 311 (JAN) 3 : 1

Solar PV Manufacturing and Packaging

This course covers manufacturing and packaging strategies for Silicon, Perovskite, and Thin-Film PV modules, preparing students for careers in PV R&D and industrial production.
Module 1: Industrial Solar Cells – From Lab to Fab
Covers key differences between lab-scale and commercial PV manufacturing. Topics include Crystalline Silicon processes (ingot growth, wafering, doping, module assembly), Thin-Film techniques (CVD, sputtering, encapsulation), and scalable Perovskite/Tandem PV processes addressing stability and integration.
Module 2: Deposition, Solution Processing & Doping Techniques
• Deposition: CVD, sputtering, co-evaporation, inkjet printing (thin-film); spin, blade, slot-die, vapour deposition (perovskites).
• Large-Area Processing: Scalable coating methods (slot-die, inkjet) for perovskite/tandem modules; film uniformity and defect control.
• Doping & Ancillary: Boron/phosphorus diffusion (Si), alkali treatments (CIGS), perovskite tuning, metallisation, encapsulation, and reliability testing.
Module 3: Packaging & Moisture Control
Explores PV module structure (cells, encapsulants, back/front sheets, junction boxes), mechanical/optical/electrical/moisture protection, and key failure modes. Covers encapsulant properties (EVA, POE, TPU), degradation, gel content, WVTR requirements, test methods (Ca-test, MOCON, CRDS), sealing challenges, and durability comparisons of glass vs. polymer sheets.
Module 4: Manufacturing Integration & Reliability
Lamination parameters (temperature, vacuum, pressure, dwell), inline QC (peel, gel, thermal), edge sealing, and junction box integration for various module types (glass-glass, bifacial, flexible). Discusses defect detection (EL, IR, IV), packaging failures (delamination, yellowing, corrosion), environmental stress testing (UV, heat, humidity), and standards (IEC 61215/61730, UL 1703).
Hands-on laboratory: (1) WVTR measurements (Calcium Degradation, CRDS); (2) Degradation analysis under damp heat and UV; (3) PV module teardown for packaging layer analysis; (4) Utilise EL and IR imaging to detect packaging-related defects.

Praveen Ramamurthy , Sachin R Rondiya , Vikram Jayaram

Pre-requisites : college-level basic device physics

References : Various Handouts Distributed During Lecture Sessions

MT 251 (JAN) 3 : 0

Fracture and Fatigue

Fracture phenomenon, Theoretical fracture strength, Linear Elastic Fracture Mechanics, Stress intensity factor, Griffith’s fracture criterion, Incorporating plasticity within the realm of LEFM, R-curve, Introduction to J-integral, Design philosophy against fracture, Toughening mechanisms; Microstructural aspects of fatigue, Fatigue crack nucleation and growth, Phenomenological treatment of fatigue life, Fatigue crack growth, Assessing fatigue life under variable amplitudes, Improving fatigue life, Fatigue aware design.

Praveen Kumar , Vikram Jayaram

Pre-requisites : MT 253: Mechanical Behavior of Materials

References : “Elementary Engineering Fracture Mechanics” by David Broek
“Elements of Fracture Mechanics” by Prashant Kumar
“Fatigue of Materials” by S. Suresh

Mechanical Engineering

Preface

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 , Balachandra Suri

Pre-requistes : None

References : None

ME 228 (JAN) 3 : 0

Materials and Structure Property Correlations

This course introduces incoming students to the basic ideas of modern materials science, beginning from the smallest scale of electrons all the way to materials selection for mechanical design. We will build on preliminary undergraduate level understanding of materials structure and their implications. We will first undertake basic considerations of atomic bonding and discuss coherent structures that can form as a result. This will be followed by a review of materials thermodynamics, phases and transformations and their consequences for material structure. We will then attempt to understand how material structure can affect, and is in turn altered by, external mechanical loading. Finally, the lessons we’ve learnt by looking at structure will be summarized in the form of selection maps that are of value to engineering practice.

Debashish Das , Akshay Joshi

Pre-requistes : None

References : We will not follow a single textbook, but periodic lecture notes and reading material will be provided. Some texts that can serve as reference are: 1) LH van Vlack, Elements of Materials Science and Engineering 2) C Kittel, Introduction to Solid State Physics 3) DR Gaskell, Introduction to the Thermodynamics of Materials 4) WD Callister, Fundamentals of Materials Science and Engineering

ME 240 (JAN) 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 vib rations, 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.

Jayanth G R , Jishnu Keshavan

Pre-requistes : None

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

ME 242 (AUG) 3 : 0

Solid Mechanics

Analysis of stress, analysis of strain, stress-strain relations, two-dimensional elasticity problems, airy stress functions in recta ngular and polar coordinates, axisymmetric problems, energy methods, St. Venanttorsion, elastic wave propagation, elastic instability and thermal stresses.

Chandrashekhar S Jog

Pre-requistes : None

References : None

ME 243 (AUG) 3 : 0

Continuum 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.
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

Pre-requistes : None

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

ME 246 (AUG) 3 : 0

Introduction to Robotics

Robot manipulators: representation of translation, rotation, links and joints,direct and inverse kinematics and workspace of serial and parallelmanipulators, dynamic equations of motion, position and force control and simulation.

Jishnu Keshavan

Pre-requistes : None

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

ME 249 (JAN) 3 : 0

Fundamentals of Acoustics

Fundamentals of vibration, vibrations of continuous systems(strings and rods), I-D acoustic wave equation, sound waves in ducts, standing waves and travelling waves, resonances, complex notation, harmonic solutions,concept of impedance. Kirchoff-Helmholtz Integral Equation, spherical coordinates,spherical harmonics, Green function (Dirichlet and Neumann),Sommerfeld radiation condition, sound radiation from simple sources,piston in a baffle,pulsating sphere, piston in a sphere, vibrating free disc, scattering from a rigid sphere. Near field and far field, directivity of sources, wave guides (phase speed and group speed),lumped parameter modeling of acoustic systems,sound in enclosures(rectangular box and cylinders), Laplace Transforms and PDEs, 1-D Green Function, octave bands, sound power, decibels. Brief introduction to diffraction, scattering, reflection, refraction.

Venkata R Sonti

Pre-requistes : None

References : None

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-requistes : None

References : None

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

Pre-requistes : None

References : Humphrey, J.D., Cardiovascular Solid Mechanics, Springer-Verlag, 2002. Fung, Y. C., Biomechanics, Springer-Verlag, 1990. Holzapfel, G. A., Nonlinear Solid Mechanics, Wiley, 2000.

ME 253 (JAN) 3 : 0

Vibrations of Plates and Shells

Fundamentals of vibration, vibrations of continuous systems(strings and rods), I-D acoustic wave equation, sound waves in ducts,standing waves and travelling waves, resonances, complex notation, harmonic solutions,concept of impedance. Kirchoff-Helmholtz Integral Equation, spherical coordinates,spherical harmonics, Green function (Dirichlet and Neumann), Sommerfeld radiation condition, sound radiation from simple sources, piston in a baffle,pulsating sphere, piston in a sphere, vibrating free disc, scattering from a rigid sphere. Near field and far field, directivity of sources, wave guides (phase speed and group speed), lumped parameter modeling of acoustic systems,sound in enclosures (rectangular box and cylinders), Laplace Transforms and PDEs, 1-D Green Function, octave bands, sound power, decibels. Brief introduction to diffraction, scattering, reflection, refraction. Shell coordinates, infinitesimal distances in curved shells, equations of motion for general shell structure.

Venkata R Sonti

Pre-requistes : None

References : None

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-requistes : None

References : None

ME 257 (JAN) 3 : 0

Finite Element Methods

Linear finite elements procedures in solid mechanics, convergence, isoparametric mapping and numerical integration.Application of finite element method to Poisson equation, calculus of variations, weighted residual methods,introduction of constraint equations by Lagrange multipliers and penalty method,solution of linear algebraic equations, finite element programming.

Chandrashekhar S Jog

Pre-requistes : None

References : Cook, R.D., Malkus, D.S., and Plesha, M.E., Concepts and Applications of Finite Element Analysis,,Third Edn, John Wiley, 1989.,Bathe, K.J.,Finite Element Procedures, Prentice Hall of India,1982.

ME 259 (AUG) 3 : 0

Nonlinear Finite Element Methods

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

Narasimhan R

Pre-requistes : None

References : Bathe, K.J., Finite Element Procedures, Prentice Hall of India, New Delhi 1997. ~Zienkiewicz, O.C., and Taylor, R.L., The Finite Element

ME 261 (AUG) 3 : 0

Engineering Mathematics

Vector and tensor algebra: Sets, groups, rings and fields, vector spaces, basis, inner products, linear transformations, spectral decomposition, tensor algebra, similarity transformations, singular value decomposition, QR and LU decomposition of matrices, vector and tensor calculus, system of linear equations (Krylov solvers, Gauss- Seidel), curvilinear coordinate transformations. Ordinary and partial differential equations: Characterization of ODEs and PDEs, methods of solution, general solutions of linear ODEs,special ODEs, Euler-Cauchy, Bessel's and Legendre's equations, Sturm-Liouville theory, critical points and their stability. Complex analysis: Analytic functions, Cauchy-Riemann conditions and conformal mapping. Special series and transforms: Laplace and Fourier transforms, Fourier series, FFT algorithms,wavelet transforms.

Venkata R Sonti , Shubhadeep Mandal , Akshay Joshi

Pre-requistes : None

References : None

ME 271 (JAN) 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

Ravikrishna R V , Navaneetha Krishnan Ravichandran

Pre-requistes : None

References : None

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

Pre-requistes : None

References : Israelachvili,J.N.,Intermolecular and Surface Forces,Elsevier Publishing Company,2003.

ME 274 (JAN) 3 : 0

Convective Heat Transfer

Energy equation, laminar external convection, similarity solution, integral method, laminar internal convection, concept of full development heat transfer in developing flow, turbulent forced convection, free convection from vertical surface,Rayleigh-Benard convection.

Saptarshi Basu , Pramod Kumar

Pre-requistes : None

References : None

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-requistes : None

References : None

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

Pre-requistes : None

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

ME 289 (AUG) 3 : 0

Principles of Solar Thermal Engineering

Introduction, solar radiation – fundamentals, fluid mechanics and heat transfer, methods of collection and thermal conversion, solar thermal energy storage, solar heating systems, solar refrigeration, solar thermal elective conversion. Other applications.

G S V L Narasimham

Pre-requistes : None

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

ME 293 (JAN) 3 : 0

Fracture Mechanics

Narasimhan R

Pre-requistes : None

References : None

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

Pre-requistes : None

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 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.

Shubhadeep Mandal

Pre-requistes : None

References : None

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.

Aloke Kumar

Pre-requistes : None

References : None

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

Pre-requistes : None

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

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 stif fness, 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

Pre-requistes : None

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

ME 223 (JAN) 3 : 0

Nonlinear Dynamics of Physical Systems

Introduction to nonlinear physical, biological, and chemical systems. Low-dimensional systems: Continuous and discrete dynamical systems, primary solutions, linear stability analysis, bifurcation theory, numerical solutions to nonlinear equations (integration, root finding methods, pseudo-arclength continuation, multi-stability), phase-space description, oscillatory solutions, Poincare/first-return map, Floquet exponents and their numerical estimation Chaos: Lorenz equation and its historical origins, chaos and its characterization (leading Lyapunov exponent, fractal dimension), routes to chaos, strange attractors, universality in chaos Spatially extended nonlinear systems: Pattern forming systems, linear stability analysis, instabilities of a uniform state, 1D models for pattern forming systems (Swift–Hohenberg, reaction diffusion,Kuramoto-Sivashinsky models), nonlinear saturation, amplitude equations

Balachandra Suri

Pre-requistes :

References : Steven H. Strogatz: Nonlinear Dynamics And Chaos: With Applications To Physics, Biology, Chemistry, And Engineering Michael Cross and Henry Greenside: Pattern Formation and Dynamics in Nonequilibrium Systems Chaosbook.org by Cvitanovic et al.

ME 202 (JAN) 3 : 0

Microhydrodynamics

Fundamental principles: Governing equations and boundary conditions, scaling arguments and Stokes approximation, fundamental theorems and general properties of Stokes flows, general solutions of Stokes equations. Motion of rigid particles: Translating and rotating particles in quiescent fluid, particles in flows, motion of anisotropic particles, weak inertial effects, phoretic motion of particles. Motion of droplets: Boundary conditions at fluid-fluid interface, translating droplets in quiescent fluid, droplets in flows, thermocapillary motion of droplets, surfactant-laden droplets, electrohydrodynamics of droplets, phoretic motion of droplets, applications to motion of capsules and vesicles. Swimming cells: Swimming at low Reynolds number, flagellar swimming, ciliary propulsion, propulsion cost and efficiency, swimming cells in flows, diffusion and noisy swimming, motion of artificial micro-swimmers.

Shubhadeep Mandal

Pre-requistes :

References : 1. D. Barthès-Biesel, "Microhydrodynamics and complex fluids", CRC Press, 2012.
2. S. Kim and S. J. Karrila, "Microhydrodynamics: principles and selected applications", Dover Publications, 2013.
3. E. Guazzelli and J. F. Morris, "A physical introduction to suspension dynamics", Cambridge University Press, 2011.

ME 217 (JAN) 1 : 2

Experimental Methods in Mechanical Engineering

This course is designed to introduce post-graduate students to basic experimental methods in mechanical engineering. The course is divided into 3 modules – the first module is comprised of elementary topics pertaining to design and execution of experiments, data analysis and signal processing, uncertainty quantification, and interfacing of measurement/actuation instruments. The second module consists of pre-set experiments and accompanying lectures, covering five different areas – basic manufacturing practice, control systems, fluid mechanics, solid mechanics and heat transfer. In the third module, students will work in groups on a project that combines concepts from the first two modules.

Susmita Dash , Koushik Viswanathan

Pre-requistes : None

References : 1. Practical Electronics – Components and Techniques by JM Hughes
2. Practical Physics by GL Squires

ME 207 (AUG) 3 : 0

Capillarity and Interfacial Phenomenon

Interfacial tension, Wetting: minimization of free energy, Dynamics of spreading, Wetting on rough surfaces, Capillary rise, Measurement of Interfacial tension, Hydrodynamics of interfaces: lubrication and thin film analysis, Interfacial instabilities, Marangoni flows, Forced wetting, Dewetting phenomena, Electrochemical transport - diffusio-osmotic and electro-osmotic flows.

Susmita Dash , Shubhadeep Mandal

Pre-requistes :

References : 1. P de Gennes, F. Brochard-Wyart and D. Quere, "Capillarity and wetting phenomena", Springer, 2004.
2. V P Carey, "Liquid-Vapor Phase-Change Phenomena", Hemisphere Pub. Corp., 1992.
3. L. G. Leal, "Advanced transport phenomena: fluid mechanics and convective transport processes", Cambridge University Press, 2007.

ME 278 (AUG) 3 : 0

A practical introduction to data analysis

•Matrix computations and visualization using python, matrix manupilations, solutions of linear equations - LU/QR/SVD/Krylov methods •Introduction to machine learning - getting started with TensorFlow/PyTorch •Supervised learning - Regressions, classifications, overfitting and generalization •Unsupervised learning - Clustering, dimensionality reduction, Self-supervised learning •Introduction to optimization problems - gradient descent, matrix-free methods like CG - getting stated with scipy.optimize and scip y.sparse.linalg modules •Constrained and unconstrained optimization problems - Lagrange multipliers, linear programming, quadratic programming, •Convex sets, functions and types of convex optimization problems-getting started with CVX_OPT/CVX_PY •Discrete and continuous random variables. Bayes' rule, Gibbs sampling, Bayesian inference - getting started with pymc

Navaneetha Krishnan Ravichandran , Balachandra Suri

Pre-requistes : None

References : 1.Probabilistic Machine Learning: An introduction, Kevin P Murphy, The MIT Press [https://probml.github.io/pml-book/book1.html] 2.Linear Algebra and Learning from Data, Gilbert Strang [https://math.mit.edu/~gs/learningfromdata/]

ME 204 (JAN) 3 : 0

Mechanics of the Elastica

The proposed course is a graduate-level elective emphasizing the interplay between geometry and elasticity. It adopts the one-dimensional Elastica model as a prototype to reveal the intricacies of geometric nonlinearity. The course will expose students to modern and exciting new structural mechanics applications, without compromising on a hands-on problem-solving experience. The subject and applications covered in the elective complement existing courses on solid, continuum, and structural mechanics in the Mechanical Sciences division. The material covered and assessment procedure will particularly benefit students engaged in research and projects related to elastic buckling, shape optimization, structural design, etc. Module 1:Linearized beam theories A relook at Euler -Bernoulli & Timoshenko beam theories -Kinematic assumptions- Constitutive assumptions -Underlying variational principles and energy minimization -Interpretation of moments and shear forces -Comparisons with linear elasticity solutions -Influence of slenderness ratios Ref: Chapter 4 of [SD] Module 2:Geometry of curves Self-contained, with emphasis on developing intuition -Parametric curves and arc length parameterization -Tangents, normal and curvature -Fundamental theorem of plane curves and its relation to beam theory Ref: Chapter 1 of [dC] Module 3:The Elastica model Sources of geometric nonlinearity and contrast with classical models -Kinematics of the centerline -Parameterization of the solution -Equilibrium equations -Elliptic integral solutions and related special functions -Phase portraits and the Kirchhoff analogy with the pendulum Ref: Chap 1 of [FF] Module 4:Special problems Amenable to closed-form solutions and graphical visualization -Transverse point loads -Follower loads -Axial loading, buckling, and post-buckled solutions -Distributed loads -Knife edge supports -Elastic foundations -The farthest-reach problem -Designing the tallest column -The elastic catapult -Circular arches Ref: Chap 2-5 of [FF] Module 5:Stability and Energy minimization Self-contained introduction, starting from multi-dof systems -Directional derivatives, first and second variations -Bifurcations points, stable and unstable branches -Stability of Elastica solutions -Vainberg's theorem on energy functionals Ref:Chap 9-10 of [KD] Module 6:Numerical continuation Self-contained introduction to computing post buckled solutions -Newton's method for nonlinear algebraic systems -Path following with Rik's method -Modal perturbations

Ramsharan Rangarajan

Pre-requistes : Undergraduate-level strength of materials, preferably a course on Solid Mechanics such as ME 242 or CE 204.

References : 1.[SD] Shames and Dym, Energy and finite element methods in structural mechanics. 2.[dC] do Carmo, Differential geometry of curves and surfaces. 3.[FF] Frisch-Fay, Flexible bars. 4.[KD] Keith Hjelmstadt, Fundamentals of structural mechanics.

ME 262 (AUG) 3 : 0

Wave Propagation in Solids

Uniaxial stress waves (equation of motion, x-t diagrams, reflection at boundaries, impedance mismatch); Uniaxial strain waves (method of characteristics); Bulk waves in 2D and 3D media (longitudinal & shear waves, Rayleigh and Stoneley waves, plane waves in 2D, reflection and refraction); Wave guides (dispersion, phase & group velocities, vibrating beams, Love waves, plate problems, 3D bar problems); Spherical waves (Impact of half spaces, Boussinesq & Lamb problems, unloading waves); Shock waves (1D shock waves, Rankine-Hugoniot relations, equation of state); Dynamic testing techniques (Split Hopkinson bars, plate impact, Taylor test, expanding ring).

Debashish Das , Akshay Joshi

Pre-requistes :

References : •M.A. Meyers, “Dynamic behavior of Materials”, Wiley, New York, NY, 1994. •J. D. Achenbach, “Wave propagation in elastic solids”, North-Holland, 1990. •H. Kolsky, “Stress waves in solids”, Dover, New York, 1963. •Zukas et al., “Impact dynamics”, Krieger, Malabar, FL, 1992. •L.M. Brekhovskikh & V. Goncharov, “Elastic Waves in Solids”, Springer, Berlin, 1994. •J. Miklowitz, “The Theory of

ME 218 (JAN) 3 : 0

Internal Combustion Engines

Overview on IC Engines, Engine Classifications, Basic Engine Components, Engines Nomenclature, Four Stroke Engines, Two Stroke Engines, Detail Working Principles of Engines, Thermodynamic Cycles, Energy Conversion, Performance Tests in Engines, Emission Tests in Engines, Dual Fuel Engines, Bharat Emission Norms, Euro Emission Norms, Combustion Process in Petrol-Diesel Engines, Combustion Chambers, Phenomenon of Knock, Ignition, Spray Process, Bio-Fuels in IC Engines, Multi Point Fuel Electronic Injection System, Cooling, Lubrication Process, Flame Propagation, Emissions Control, Carburetion, Supercharging, Turbocharging, Some Aspects of Engine Electronics, Artificial Intelligence and Machine Learning Application in Engine Combustion.

R Thirumaleswara Naik

Pre-requistes : None

References : 1.Heywood JB, Internal Combustion Engine Fundamentals, MIT-USA, McGraw-Hill, 1998. 2.Ganesan V, Internal Combustion Engines, IIT-IND, Tata Mc Graw-Hill, 1999. 3.Ehsani M, Yimin G and Emadi A, Modern Electric, Hybrid Electric and Fuel Cell Vehicles, TAMU-USA, CRC Press, 2010.

ME 307 (JAN) 3 : 0

Singularities and Scaling Laws

This is a post-graduate level course on applied mathematics that will deal with singularities in mathematical models and methods used to resolve/solve them. A list of topics includes: Similarity solutions; scaling analysis in fluid and solid mechanics; power laws; introduction to asymptotic analysis; introduction to singular perturbation theory; analysis of singularities in interfacial flows and dynamics; Moffatt eddies; Reimann-Hilbert problems; similarity laws in fracture mechanics.

Gaurav Tomar , Koushik Viswanathan

Pre-requistes :

Undergraduate Fluid and Solid Mechanics, Engineering

References : Scaling, Self-similarity, and intermediate asymptotics - Grigory Isaakovich Barenblatt
Singularities in fluid mechanics – J Eggers
Introduction to fluid mechanics – G K Batchelor

Dept. of Design and Manufacturing

Preface

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.

Satyam Suwas

Pre-requistes : None

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

Pre-requistes : None

References : None

MN 203 (JAN) 3 : 0

Design for Additive Manufacturing

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

Gurumoorthy B , Ananthasuresh G K

Pre-requistes : None

References : None

MN 204 (JAN) 3 : 0

Human Machine Interaction for Manufacturing

Cognitive Psychology: Basic principles visual and auditory perception, top down and bottom up processing of visual and acoustic signal, memory structure,sensory, short term, long term memory, classification of error, memory retrieval process, rapid aiming movement, Fitts' Law, Implication in interaction design, User Modelling Introduction to Ergonomics, anthropometry and biomechanics, sensory capability and display design, display-control compatibility, spatial arrangements and interaction, manual and VR interactions, human error causes and mitigation. Ergonomic Principles:Usability Evaluation – Different methods of usability evaluation, Heuristics evaluation, Cognitive Walkthrough, Think Aloud Protocol, Cognitive Dimension of Notation, Simulation, User Trial Design, Statistical Hypothesis Testing, t- test, ANOVA AR/VR/Haptics Technologies: History of AR/VR, Difference among AR/VR/MR, Basics of Image Processing, Filtering, Edge and shape detection,Optics of VR headsets.

Pradipta Biswas

Pre-requistes : None

References : • Shneiderman B. "Designing The User Interface - Strategies for Effective Human-Computer Interaction." Pearson Education • Buxton B., Sketching User Experiences: Getting the Design Right and the Right Design, Morgan Kaufmann • Field A. Discovering Statistics Using SPSS, SAGE Publications Ltd., 2009. • The Wiley Handbook of Human Computer Interaction Set, John Wiley & Sons

MN 205 (AUG) 1 : 2

Makers' Project

Each maker's project will be offered to be carried out in groups of 4-5 students. The course will involve two components: a common primer on metrology of mechanical, electrical, optical, contact and non-contact measurements (about 4 weeks, to be taught by appropriate faculty from the programme),followed by carrying out a single project by each group (8 weeks). The project will be allotted from a list of 'assemble- program-characterize' projects to be shared with students each year.

Vishal Singh

Pre-requistes : None

References : None

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.

Vishal Singh

Pre-requistes : None

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.

Manish Arora

Pre-requistes : None

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

Pre-requistes : None

References : Jones, J.C., Design Methods, John Wiley, 1981.,Cross, N., Engineering Design Methods, John Wiley, 1994.,Pahl, G., and Beitz, W., Engineering Design, Design Council, 1984.,Brezet and van Hammel, ECODESIGN – A promising approach to sustainable production and consumption, UNEP Manual

PD 205 (JAN) 2 : 1

Materials, Manufacturing and Design

Material usage and sustainability issues, concept or closed and open loop.Engineering materials, metals and their properties, uses, processing methods,design data and applications, material selection criteria, manufacturing and processing of materials. Plastics and composites, types, classification,properties, processing techniques and limitations, basics of reliability,failure and failure analysis.

Anindya Deb

Pre-requistes : None

References : Dieter, G.E., Engineering Design – A Materials and processing approach, McGraw Hill, 1991.,Ashby, M.F., Materials selection in Mechanical Design, Pergamon press, 1992.,Patton, W.J., Plastics Technology, Theory, Design and Manufacture, Lenton Publishing Co.

PD 207 (AUG) 1 : 2

Product Visualization, Communication and Presentation

Object drawing fundamentals, theory of perspectives, exploded views, sectional views. Fundamentals of lighting, idea representation and communication methods and pitfalls. Materials, tools and techniques of representation in various media like pencil, ink, colour etc. Rendering techniques, air brush illustration. Idea documentation. Fundamentals of photography, video-graphy and digital media. Dark room techniques. Studio assignments in all the above topics. Mock-up modeling and simulation in various materials.

N D Shiva Kumar

Pre-requistes : None

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

Vishal Singh

Pre-requistes : None

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 211 (JAN) 2 : 1

Product Design

Semiotic studies – product semantics, syntactics, and pragmatics. Study of expressions, metaphors, feelings, themes. Study of product evolution, problem identification, design methods, design process, design brief, concept generation, concept selection, design and development, product detailing,prototyping, design evaluation.

Vishal Singh

Pre-requistes : None

References : Papanek, V., Design for the Real World, Thames & Hudson, London.,Ulrich, K.T.,and Eppinger, S.D., Product Design and Development,Tata McGraw Hill, India.

PD 215 (JAN) 2 : 1

Mechatronics

Introduction to mechatronics – overview of mechatronic products and their functioning. Survey of mechatronical components, selection and assembly for precision-engineering applications. Study of electromechanical actuators and transducers. Load analysis and actuator selection for typical cases such as computer peripherals. Study of electronic controllers and drives for mechanical products. Interfacing of mechanical and electronic systems. Design assignments and practical case studies.

Manish Arora , Abhra Roy Chowdhury

Pre-requistes : None

References : Bolton, W Mechatronics, Longman, 2015,Kuo, B.C., D.C.Motors and Control systems, SRL Publishing Co., 1979.,Kuo, B.C., Step Motors and Control Systems, SRL Publishing Co., 1979.

PD 217 (AUG) 2 : 1

CAE in Product Design

Product development driven by concurrent engineering, role of Computer- AidedEngineering (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

Pre-requistes : None

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 218 (JAN) 1 : 2

New Product Development: Strategy and Practice

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

Vishal Singh

Pre-requistes : None

References : None

PD 231 (JAN) 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

Pre-requistes : None

References : Sanders and McCormick,Human Factors in Engineering and Design,Seventh Edn,McGraw Hill

PD 233 (AUG) 2 : 1

Design of Biomedical Devices and Systems

Medical Device Classification, Bioethics and Privacy, Biocompatibility and Sterilization Techniques,Design of Clinical Trials, Design Control & Regulatory Requirements, Introduction to specific medical technologies: Biopotentials measurement (EMG, EOG, ECG, EEG), Medical Diagnostics (In vitro diagnostics), Medical diagnostics (Imaging), Minimally Invasive Devices,Surgical Tools and Implants, Medical Records and Telemedicine. The course will include guest lectures by healthcare professionals giving exposure to ummet needs in the healthcare technologies and systems.

Manish Arora

Pre-requistes : None

References : Paul H king, Richard C. Fries, Arthur T. johnson, Design of Biomedical Devices and Systems. Third edition, ISBN 9781466569133,Peter J.Ogrodnik, Medical Device Design:Innovation from Concept to Market, Academic Press Inc; ! edition (2012), ISBN-10:0123919428,Stefanos Zenios, Josh Makower, Paul Yock, Todd J.Brinton, uday N. Kumar, Lyn Denend, Thomas

PD 234 (AUG) 2 : 1

Intelligent User Interface

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

Pradipta Biswas

Pre-requistes : None

References : Shneiderman B. "Designing The User Interface - Strategies for Effective Human-Computer Interaction.",Buxton B., Sketching User Experiences: Getting the Design Right and the Right Design, Morgan Kaufmann,Norman K (Ed), Wiley Handbook of Human Computer Interaction, Wiley 2017

PD 236 (JAN) 2 : 1

Embodiment Design

Introduction to design research, a methodology for design research and its components, types of design research, selecting criteria and its research methods, understanding factors influencing design and its research methods,developing design support and its research methods, evaluating design support and its research methods, associated exercises and tests. Embodiment methodology, basic components and interfaces, design for performance including strength, usability, maintenance and reliability, Designfor manufacturing, assembly, packaging, distribution, services, cost and environmental impact. Dimensioning, tolerance and standards.

Amaresh Chakrabarti , Abhijit Biswas

Pre-requistes : None

References : Blessing, L.T.M., Chakrabarti, A., and Wallace, K.M., An Overview of Design Studies in Relation to a Design Research Methodology. ,Frankengerger and Badke-Schaub (Eds), Designers: The Key to Successful Product Development, Springer Verlag, 1998.,Current Literature including papers from Proceedings of the International Conference in Engineering Design, Prague, 1995 Pahl, G

PD 239 (AUG) 0 : 3

Design and Society

Independent study/research on a chosen topic by students under the supervisionof 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.

Vishal Singh

Pre-requistes : None

References : None

PD 216 (AUG) 2 : 1

Design of Automotive Systems

Classification of automotive systems, interfacing of marketing, design and manufacturing, converting customer's needs into technical targets, vehicledesign process milestones with a systems engineering approach, trade-off studies, manufacturing cost and economic feasibility analysis. Design tools such as reverse engineering, rapid prototyping, CAD/CAE, Taguchi methods, andFMEA. Styling concepts and features, ergonomics, packaging and aerodynamics.Review of vehicle attributes (NVH,durability, vehicle dynamics, crash safety,etc.). Overview of automotive technology (body, power train, suspension systems, etc.).

Anindya Deb

Pre-requistes : None

References : Ulrich, K.T., and Eppinger, S.D., Product Design and Development, Second Edn, Irwin McGraw Hill,Gillespie, T.D., Fundamentals of Vehicle Dynamics, SAE Inc.., Schwaller, A.E., Motor Automotive Technology, Third Edn, Delman Publishers

PD 230 (JAN) 3 : 0

Haptic Systems Design

Abhijit Biswas

Pre-requistes : None

References : None

PD 204 (AUG) 2 : 1

Basics of Electronics for Product Design and Manufacturing

Introduction to sensors and actuators, Static vs. current electricity, Passive and active components of electrical systems, Type of electrical sources, Introduction to linear and non-linear electrical components, Basic circuit theory and analysis of DC circuits, Basics of AC circuit, Basics of power distribution, domestic and industrial electrical wiring and safety, AC-AC and AD-DC conversion, Voltage regulator, Constant current source, Sensor biasing (voltage vs. current biasing) and transduction, Transistors: Type and application as amplifier and switch, Basic op-amp circuit, Introduction to digital logic, Combinational and sequential circuit, Discrete signals: Number systems and binary arithmetic, Logic gates, Flip-Flops, Sampling theory, Sampling and hold circuit, anti-aliasing filter, Digital to Analog (DAC) and Analog to Digital (ADC)Conversions, Different types of ADC and DAC with their benefits and limitations, Basics of Microprocessors and microcontrollers. Introduction to sens

Abhijit Biswas

Pre-requistes : Students without electrical or electronics or instrumentation or similar background perusing higher study in interdisciplinary fields

References : •Roy Choudhury, D. (1988). Networks and Systems. India: Wiley Eastern. •Jain, B., Jain, S., Roy Choudhury, D.(2010).Linear Integrated Circuits. United Kingdom: New Age Science Limited. •M.Morris Mano and Michael D. Ciletti, Digital Design, Pearson, Prentice Hall, https://archive.org/details/morrismano4thedition/page/n 1/mode/2up •Dam, B. v. (2009). Microcontroller Systems Engineering:45

PD 206 (AUG) 2 : 1

Basics of Computing, AI and Data Science for Design and Manufacturing

Introduction to sensors and actuators, Static vs. current electricity, Passive and active components of electrical systems, Type of electrical sources, Introduction to linear and non-linear electrical components, Basic circuit theory and analysis of DC circuits, Basics of AC circuit, Basics of power distribution, domestic and industrial electrical wiring and safety, AC-AC and AD-DC conversion, Voltage regulator, Constant current source, Sensor biasing(voltage vs. current biasing) and transduction, Transistors: Type and application as amplifier and switch, Basic op-amp circuit, Introduction to digital logic, Combinational and sequential circuit, Discrete signals:Number systems and binary arithmetic, Logic gates, Flip-Flops, Sampling theory, Sampling and hold circuit, anti-aliasing filter, Digital to Analog (DAC) and Analog to Digital (ADC)Conversions, Different types of ADC and DAC with their benefits and limitations, Basics of Microprocessors and microcontrollers.

Abhijit Biswas

Pre-requistes : Students without computer science or data science or information technology or similar background perusing higher study in interdisc

References : •Roy Choudhury, D. (1988). Networks and Systems. India: Wiley Eastern. •Jain, B., Jain, S., Roy Choudhury, D.(2010).Linear Integrated Circuits. United Kingdom: New Age Science Limited. •M.Morris Mano and Michael D. Ciletti, Digital Design, Pearson, Prentice Hall, https://archive.org/details/morrismano4thedition/page/n 1/mode/2up •Dam, B. v. (2009). Microcontroller Systems Engineering:45

MN 207 (AUG) 2 : 1

Intelligent Mobile Robots: Perception, Action and Control

Introduction to Mobile Robotics Locomotion Principles Kinematic Modelling Perception Control System Design Localization Motion Planning Multi-robot systems ROS and Matlab for Robotics Autonomy in Mobile Robot

Abhra Roy Chowdhury

Pre-requistes :

References : • H. Choset, K. M. Lynch, S. Hutchinson, G. Kantor, W. Burgard, L. E. Kavraki, and S. Thrun, Principles of Robot Motion: Theory, Algorithms and Implementations, PHI Ltd., 2005. • R. Siegwart, I. R. Nourbakhsh, Introduction to Autonomous Mobile Robots, MIT Press,2011 • G. Dudek and M. Jenkin, Computational Principles of Mobile Robotics, Cambridge University Press, 2010 • H. Asama, T.

MN 299 (AUG) 0 : 24

Dissertation Project

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

Vishal Singh

Pre-requistes : None

References : -

PD 298 (AUG) 0 : 22

Dissertation Project

Spread over 15 months, commencing immediately after the second semester. It involves complete design, prototype fabrication, demonstration of requirement satisfaction along with full documentation.

Vishal Singh

Pre-requistes : None

References : Gerhard Pahl , Wolfgang Beitz , Jörg Feldhusen , Karl-Heinrich Grote, Engineering Design A Systematic Approach, Springer, ISBN:978-1-84628-318-5

Mobility Engineering

Preface

MO 201 (AUG) 3 : 0

Introduction to Hybrid Electric Vehicles

•Introduction to Conventional IC Engines •Description of various types of hybrid powertrains •Pros and cons of various hybrid powertrains and their effect on performance and complexity •Sizing of powertrains in micro, mild, full hybrids, as well as plug-in hybrids •Energy Management System and control of various hybrid powertrain modes •Simulation of Hybrid Electric Vehicles on various drive cycles in MATLAB Simulink

Ravikrishna R V

Pre-requistes : None

References : 1. Modern Electric, Hybrid Electric, and Fuel Cell Vehicles: Fundamentals, Theory, and Design, Mehrdad Ehsani, Yimin Gao, Sebastien E. Gay, Ali Emadi, CRC Press, 2005.

MO 210 (AUG) 1 : 0

Seminar

Exposure to latest topics in research and industry

Ravikrishna R V

Pre-requistes : None

References : Not applicable

MO 299 (JAN) 0 : 30

Dissertation Project

Dissertation Project

Ravikrishna R V

Pre-requistes : None

References : Not applicable

Division of Physical and Math. 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

Cryogenic Technology

Preface

CCT 303 (AUG) 3 : 0

Cryoelectronics for Space Science

Cryogenics in space science and the need for cryoelectronics; Cryocoolers for space applications; Developments in cryoelectronics: superconductivity and its occurrence, survey of superconducting materials, Meissner Effect, BCS theory of superconductivity, Type I and Type II superconductors, Flux quantization, Josephson tunnelling, AC and DC Josephson effects, HTS superconductors, SQUIDs and their applications; Cold Electronics: Electronics based on semiconductors at cryogenic temperatures, improvements in their performance through material related properties such as mobility, thermal and electrical conductivities, associated problems due to thermal contraction mismatch and thermal cycling; Electronics for space exploration missions – performance of conventional transistors, oscillators, A/D converters, DC/DC converters, PWM controllers, components and systems at cryogenic temperatures; Cryocoolers for space missions: Development of different cryocoolers and their electronics for Space missions for specific use under European Space Agency; Cryoelectronics for miscellaneous applications: IR detectors in space missions, memory technology and readout electronics, SC Qubit control and readout.

Nadig D S

Pre-requistes :

Nil

References : 1. E. A. Gutierrez, J. Deen and C. Claeys, Low temperature electronics: Physics, devices, circuits and applications, Elsevier Publishing

CCT 302 (AUG) 2 : 1

Single Molecule Imaging and Cryoelectron Microscopy

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, Photophysics 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. Cryoelectron Microscope Instrumentation, Electron Gun, Electron Lenses, Vacuum Systems, Sample Chamber, Energy Filters, Electron Detectors, Electron Scattering, Point Spread Function, Fourier Transform, Image formation. Dedicated Lab Sessions & Practical on Fluorescence, Light Sheet, Cryoelectron and Single Molecule Super-resolution Microscopy.

Partha Pratim Mondal

Pre-requistes :

Nil

References : 1.J. R. Lakowicz, Principles of Fluoresence Spectroscopy, Springer Publisher, 2006. 2.Partha Pratim Mondal, Fundamental of Fluoresence Microscopy, Springer Publisher, 2014. 3.T. Gonen and B. L. Nannenga, CryoEM: Methods and Protocols, Humana Press, 2021.

CCT 201 (AUG) 3 : 0

Cryogenic Technology: Fundamentals and Applications

Introduction and fundamentals of cryogenic technology; Properties of cryogenic fluids: nitrogen, oxygen, argon, neon, fluorine, methane; Low temperature properties of materials: mechanical, thermal, electrical and magnetic properties; Physics of liquefaction and liquefaction systems; Cryogenic fluid storage and transfer systems: cryogenic fluid storage vessels design and insulations, cryogenic fluid transfer systems; Gas liquefaction systems: thermodynamically ideal system, production of low temperatures, liquefaction systems for gases other than neon, hydrogen and helium, liquefaction systems for neon, hydrogen and helium; Cryogenic refrigeration systems: ideal refrigeration systems, refrigeration for temperature above 2 K, refrigerators for temperature below 2 K; Introduction to cryocoolers; Cryogenic safety; Cryogenic instrumentation: temperature, pressure, flow and liquid level measurements; Vacuum technology: Importance of vacuum in cryogenics, flow regimes in vacuum systems, conductance in vacuum systems, calculation of pump down time, basic components of vacuum systems, basics of vacuum pumps, gauges and valves; Application of cryogenics: space, medical, biological, food preservation and industrial applications.

Upendra Behera

Pre-requistes :

Nil

References : 1.T.Bradshaw, B. Evans and J. Vandore, Cryogenics: Fundamentals, foundations and applications, IOP Publishing, 2022. 2.R. F.Barron, Cryogenic Systems, Oxford Unversity Press, 2nd Edition. 1985. 3.G. G.Haselden, Cryogenic fundamentals, Academic Press, New York. 1972.

High Energy Physics

Preface

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.

B Ananthanarayan

Pre-requistes : None

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,

HE 392 (AUG) 3 : 0

String Theory

"Bosonic Strings: closed and open, oriented and unoriented. Light cone quantization and spectrum. Polyakov path integral. BRST symmetry. Conformal field theory. Modular invariance. Boundary states. Classical and quantum superstrings. Spin structures and GSO projection. Type II strings. D-branes and Type I strings. Torus compactification and Heterotic strings.Current algebras and lattices. Bosonization. N=1,2 superconformal field theory. "

Chethan Krishnan

Pre-requistes : None

References : "Green M.B., Schwarz J.H. and Witten E., Superstring Theory, Vol. I and II,Cambridge University Press, 1989.Polchinski J., String Theory, Vol I and II,Cambridge University Press, 2005.Kiritsis E., String Theory in a Nutshell,Princeton University Press, 2007. "

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.

Prasad Satish Hegde

Pre-requistes : None

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~

HE 398 (AUG) 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.

Sachindeo Vaidya

Pre-requistes : None

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

HE 315 (JAN) 3 : 0

Advanced Mathematical Physics

Introduction to differential geometry, Calculus on manifolds. Tensor analysis. Connection and covariant derivative. Riemannian geometry, curvature and torsion. Introduction to topology, Manifolds and homotopy. Fibre bundles, Gauge theories. Applications of the above to physics.

Justin Raj David

Pre-requistes :

References : 1. Modern Geometry - Methods and Applications Parts I & II, by B. A. Dubrovin, A. T. Fomenko and S. P. Novikov2. Lectures on Advanced Mathematical Methods for Physicists, by S. Mukhi and N. Mukunda.

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.

Chethan Krishnan

Pre-requistes : None

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

HE 379 (AUG) 3 : 0

Physics Beyond Standard Model

Higgs discovery and its implications, effective field theories, supersymmetry and supergravity, extra dimensions and its variants, composite Higgs models, Cosmological solutions like relaxions and its variants, neutrino masses and GUTS, axions, and modern probes of new physics.

Sudhir Kumar Vempati

Pre-requistes :
Advanced graduate students, all qft courses and the Standard Model course.

References :
Csaki's lecture notes, orignial papers.

HE 381 (AUG) 3 : 0

Quantum Field Theory on a Quantum Computer

This course aims to explore the forefront of research in understanding quantum field theory (QFT) through the lens of quantum computing. Students will begin by examining the fundamental principles of QFT, including the quantization of scalar and fermionic fields. Building upon this, we will delve into the discretization of quantum fields on a lattice, which enables the use of computational methods for non-perturbative problems and facilitates quantum simulations. A significant focus will be placed on encoding quantum field theories onto qubits, where techniques such as Jordan-Wigner and Bravyi-Kitaev transformations will be introduced to map fields and interactions onto digital quantum systems. The course will also cover scattering theory within the quantum simulation framework, emphasizing how particle interactions and scattering amplitudes can be studied using quantum algorithms. Additionally, an introduction to continuous-variable quantum computing (CVQC) will be provided, highlighting alternative approaches to quantum simulation that utilize bosonic modes and CV gates, which are particularly suited for simulating quantum fields. Practical applications and demonstrations will be carried out using quantum simulators such as Qiskit, for digital qubit-based models, and Strawberry Fields, which specializes in continuous-variable quantum information processing. Overall, this course will blend theoretical insights with practical skills, equipping students with a modern understanding of how noisy intermediate scale or futuristic quantum computers can be harnessed to explore quantum field theories.

Aninda Sinha

Pre-requistes :
Quantum mechanics 1 and 2 (PH203, PH204); Quantum Field Theory 1 is desirable.

References : 1.Quantum Computation and Quantum Information-- Nielsen and Chuang, Cambridge University Press, 2010
2. Quantum field theory and the Standard model---Matthew Schwartz, Cambridge University Press, 2014
3. IBM QISKIT https://www.ibm.com/quantum/qiskit

Instrumentation and Applied Physics

Preface

IN 201 (AUG) 3 : 0

Analytical Instrumentation

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

Manukumara Manjappa

Pre-requistes : None

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

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 , Baladitya Suri

Pre-requistes : None

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 227 (AUG) 3 : 0

Control Systems Design

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

Jayanth G R

Pre-requistes : None

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

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 , Tapajyoti Das Gupta

Pre-requistes : None

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

IN 234 (JAN) 3 : 0

Biomedical Optics and Spectroscopy

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

Jaya Prakash

Pre-requistes : None

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

IN 270 (AUG) 3 : 0

Digital Signal Processing

Signals and Systems Review, Time scaling and shifting, Amplitude scaling and shifting, LTI Systems, Properties of Signals and Systems, CTFS, CTFT, Nyquist Sampling Theorem, Reconstruction of Bandlimited Signals, DTFS, DTFT, Discrete Fourier Transform, Properties of Fourier Transform, existence of Fourier Transform. Laplace transform and its properties, z-transform and its properties. Signal Flow graphs, FIR and IIR filter realization. Impulse invariance method, and Bilinear transformation. Low-Pass Filtering, Filter design-Chebyschev Filter, Butterworth Filter and linear-phase filters. Windowing and Parks-McClellan Algorithm. Multi-resolution analysis, Filter Banks, Short-time Fourier Transform, Wavelets. 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, Majorization-Minimization, and Compressive Sampling.

Jaya Prakash

Pre-requistes :

Signals and Systems & consent from the instructor

References :

Textbooks:

IN 302 (AUG) 3 : 0

Classical and Quantum Optics

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

Partha Pratim Mondal

Pre-requistes : None

References : None

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

Pre-requistes : None

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 203 (AUG) 3 : 0

Micro to Quantum Supercapacitor Devices

Fundamentals of supercapacitor, Supercapacitor Fabrication, State-of-art supercapacitor design, Supercapacitor materials, Macro supercapacitor, Planar micro supercapacitor, Self-powered supercapacitor, Design of planar supercapacitor electrodes, Differences in macro-supercapacitor and planar supercapacitors, Mechanism of electrochemical interactions, Energy density and power density, Fundamentals of electromagnetic interaction in device design, Optically active devices and circuit design, Instrumentation of supercapacitor, Flexible electronics of supercapacitor, Ultra small planar devices, Device design parameters, Quantum Supercapacitors, Current technological advancements and future roadmap, Future Applications

Abha Misra

Pre-requistes :

References : 1- Electrochemical Supercapacitors, Author: B E Conway. 2- Semiconductor Devices and Circuits (Oxford Higher Education), by Aloke Dutta 3- Physics of Optoelectronics, by Michael A. Parker

IN 277 (AUG) 2 : 1

Instrumentation Electronics Laboratory

Applications of operational amplifiers, active filters, oscillators, A/D and D/A converters, phase-locked loops, mixers, lock-in amplifiers, switched mode power supplies, speed control of motors using PWM, introduction to microcontrollers and microprocessors. (There will be lectures and laboratory sessions on each of the topics mentioned here.)

Atanu Kumar Mohanty

Pre-requistes :

References : *Paul Horowitz and Winfield Hill, The Art of Electronics, Cambridge University Press, 2015 *Jacob Millman and Christos C. Halkias, Integrated Electronics, McGraw-Hill International Student Edition,1972 *Robert W. Erickson and Dragan Maksimovic, Fundamentals of Power Electronics, Springer, 2001 *R.S. Kaler, Microprocessors and Microcontrollers, I. K. International Publishing

IN 299A (JAN) 0 : 20

M Tech Project

Research project for fulfillment of M Tech degree requirements

Baladitya Suri

Pre-requistes : None

References : Project-specific references

IN 278 (JAN) 2 : 1

Introduction to Embedded Systems

Introduction to the embedded systems landscape and the importance of programming, operating systems, middleware, interfacing, design, debugging and testing. B)Role of the microcontroller. Introduction to modern computing architecture. Highlights of microcontroller architecture, GPIO, UART, and hardware protocols such as SPI and I2C. C)Representative sensors and actuators and interfacing these to microcontrollers. D)Representative tasks – sensing, actuating, processing E)Interconnecting microcontrollers and protocols. F)Designing and debugging embedded systems. G)Emerging topics and issues related to embedded systems. H)Laboratory activities will be designed to provide training and practice for students to design and deploy a range of embedded systems without using a real-time operating system.

Baladitya Suri

Pre-requistes :

Basic Knowledge of C programming

References : 1.Hennessey and Patterson, Computer Organization 2.E.A. Lee and S.A. Seshia, Introduction to Embedded Systems 3.P. Marwedel, Embedded Systems Design, Springer 2006 4.J. Yiu, Definitive Guide to ARM M3 Architecture

IN 332 (JAN) 3 : 0

2D MATERIALS

Introduction to low dimensional materials - 0D, 1D, 2D; properties of conventional 2D electron gases; introduction to layered 2D materials, atomic structure of graphene and other layered materials, electronic band structures of single and bilayer graphene, production of 2D materials; Raman spectroscopy and other characterization techniques; device fabrication and measurement techniques; quantum Hall effect in graphene-based systems; electronic and electromechanical properties; optical properties; sensors; membranes; van der Waals heterostructures; moiré physics

Chandni U

Pre-requistes :
UG level Quantum Mechanics and Solid State Physics (PH 203 or equivalent, IN232/PH208 or equivalent)
References : 1.2D Materials: Properties and Devices, edited by Avouris, Heinz and Low, Cambridge University Press 2.The Physics of Low Dimensional Semiconductors, John M. Davies, Cambridge University Press 3.Solid State Physics, N. Ashcroft and N. D. Mermin, Saunders College Publishing

IN 303 (JAN) 3 : 0

Concepts of Terahertz Communication

1.Maxwell’s Equations, Poynting’s Theorem, Boundary Conditions (4 hours) In this section, the course will introduce and discuss the fundamental laws governing electromagnetism, starting with Maxwell's equations. The Maxwell's equations are pivotal in governing and describing how electric and magnetic fields generate, interact and propagate in medium and in free space. We then explore Poynting's theorem, which provides a framework for understanding energy transfer in electromagnetic fields, and the flow of electromagnetic power through space. The boundary conditions will be discussed, which are essential for solving Maxwell's equations in different media, ensuring the continuity of tangential components of electric and magnetic fields across interfaces. 2. Wave Equations, Plane Waves, Polarization, Conduction and Polarization Currents, Diffraction and Scattering (6 hours) This part introduces the wave equation, derived from Maxwell’s equations, which describes the propagation of electromagnetic waves. We will investigate plane waves, their characteristics, and significance in the signal propagation. Polarization, a critical property of transverse waves indicating the orientation of the electric field, will be discussed in detail. Furthermore, we will examine conduction and polarization currents, essential concepts in understanding the movement of charges and dipoles in materials. Finally, we will cover the diffraction and scattering phenomena, which describe the behavior of waves in a scattering media, crucial for applications in optics and telecommunications. 3.EM Waves Propagation in Waveguides and Resonant Cavities, Eigen Modes, Phase and Group Velocity (6 hours) Here, we will focus on the propagation of electromagnetic waves within waveguides and resonant cavities, structures that confine and direct waves. We will analyze eigenmodes, the natural resonant modes of these systems, which are vital for understanding the operational characteristics of the communication/resonant devices. The concepts of phase and group velocity, describing the speed at which individual wave fronts and wave packets travel, will be thoroughly examined to provide insights into signal transmission and dispersion in guided wave systems. 4.Dipole Radiation, Antennas, Multiplexers, Beam Steering and Beam Forming (8 hours)In this section, we will explore the principles of dipole radiation, the fundamental mechanism of how antennas emit electromagnetic waves. We will cover various types of antennas, their design, and operational principles. Multiplexers, devices that combine multiple signals into one for transmission and then separate them at the receiver, will be discussed. The concepts of beam steering and beam forming, techniques used to direct the radiation pattern of antennas to enhance signal strength and quality in desired directions, are crucial for modern communication systems. 5.Hybrid Electronic-Photonic Systems, High Frequency Diodes, Sources, and Detectors (8 hou

Manukumara Manjappa

Pre-requistes :
Waves and Optics, Basic electronics; Semiconductors/Solid state physics

References : 1.Classical Electrodynamics, John David Jackson,1999 (3rd Edn). 2.Introduction to Terahertz Electronics, Jae-Sung Rieh, Springer Nature Switzerland AG 2021 Edn. 3.High-frequency Electrodynamics, Boris Z. Katsenelenbaum, Wiley-VCH 2006 Edn.

IN 279 (JAN) 2 : 1

RF networks and Systems

The course will cover the following topics -- Review of Transmission line theory, Lumped versus Distributed elements concept, lossless and lossy lines, line impedance, concept of reflection, transmission. General solutions for TEM, TE and TM waves. Introduction to stripline and microstripline, Wheeler charts, Graphical design tehnique using Smith chart. Network Synthesis: N-port RF networks, impedance, admittance, transmission and scattering matrix representations, reciprocal and lossless networks, network matrices transformations, Impedance matching and tuning: L-section impedance matching, Quarter wave transformer, Distributed matching: single and double stub matching. Practical application scenarios, Microwave passive circuits: Waveguide cavity resonators. Principles of power dividers, splitters, 90 degree hybrid directional couplers, 180 rat race couplers, Design of Wilkinson power divider, Filter design: Figure of Merit, Design of High Pass, Low pass, BPF using Chebyshev, butterworth and maximally flat response types. Lumped and distributed realizations will be covered. In the second part of the course we will also discuss RF transceiver systems and subsystems. Under this the following topics will be covered -- Noise: Noise representation as a noise voltage, types of noise in typical RF systems, Noise Figure concept, Signal to noise ratio, and methods to measure system noise such as Y factor method, Active devices basics: Review of diodes, BJTs and MOSFETs, Amplifiers, concept of gain compression, non-linearities, Dynamic Range and third order intercept point, Amplifier design: Stability concept, gain circles, choice of device, design of input and output matching stages. Amplfier characterization using VNA , Low Noise amplifier design: Choice of device, noise circles, design of matching networks with trade-off

Baladitya Suri

Pre-requistes :
RLC circuits, Analog electronics, EM wave theory, Time and Frequency Domain analysis, Probability Theory and Random Processes,

References : Microwave Engineering, David M. Pozar, 4th Edition, Wiley 2012 RF circuit design, Christopher Bowick, 2nd edition, Elsevier 2011 Fun damentals of Microwave and RF design, Michael Steer, 3rd edition, NC State University , 2019

IN 321 (JAN) 0 : 3

Instrumentation Systems Laboratory

This course focuses on developing various instrumentation systems through group-based projects. Each project would include one or more of the following activities: development and characterization of the necessary sensors and actuators, development of drivers and signal conditioning circuitry, programming of microcontrollers, dynamic modeling and control system design, data interpretation and error analysis.

Atanu Kumar Mohanty , Jayanth G R , Baladitya Suri

Pre-requistes :

IN 221

References : (1) The Art of Electronics, P. Horowitz, W. Hill, Cambridge University Press (2015)
(2) Measurement Systems, E. O. Doebelin, D. N. Manik, McGraw Hill Education (2017)
(3) Control System Design, G. C. Goodwin, M. Salgado and S. F. Graebe, Pearson (2000)

IN 205 (AUG) 0 : 3

Optical Instrumentation lab 1

1. Ray Optics: Basic Ray Optics Setup, Telescope Configuration (Beam Expansion/Collimation), Measuring Intensity Profile, Data Analysis
2. Spectroscopy: Beer-Lambert Law, Design of Absorption Spectrophotometer, Fluorescence Spectrophotometer, Role Played by Scattering, Baseline Correction, Multi-point Normalisation, Sample preparation, Spectrophotometer Characterization, Calibration, Operation, Data acquisition, Analysis, and Interpretation. Students would gain hands-on experience in the design and construction of Optical Absorption Spectrophotometer and its characterization. Experimental means of measuring the spectral resolution, Sensitivity, Accuracy, and Precision. Exposes them to different means of acquiring spectral data, analysis algorithms and interpretation of spectral features, and relating them to the properties of the analyzed material.
3. Interferometry: Michelson Interferometer, To measure the wavelength of a monochromatic light source (e.g., laser), To determine the coherence length of the light source, To analyze how path difference affects interference patterns, To interpret fringe visibility and its relation to coherence.

4. Design and Simulation: Using Ansys Zeemax design of various interferometer, ray optics experiments

Sai Siva Gorthi , Jaya Prakash , Tapajyoti Das Gupta

Pre-requistes : None

References : 1.Optics by Ajoy Ghatak, Mc Graw Hill, Higher education 2010
2. Basics of Interferometry (Second Edition) by P. Hariharan, Academic Press, 2007
3. Optics, Eugene Hecht, Pearson; 5th edition 2016

IN 204 (AUG) 0 : 3

Basic Instrumentation Laboratory

Analogue and Digital Electronics: Experiments on operational amplifiers, active filters, oscillators, A/D and D/A converters, phase-locked loops, mixers, lock-in amplifiers, switched mode power supplies, speed control of motors using PWM. Experiments on Control Systems, Sensors and Transducers.

Atanu Kumar Mohanty , Jayanth G R , Baladitya Suri

Pre-requistes : None

References : * Paul Horowitz and Winfield Hill, The Art of Electronics, Cambridge University Press, 2015

IN 305 (JAN) 0 : 3

Optical Instrumentation Lab 2

This course provides a comprehensive introduction to advanced optical techniques, combining theoretical foundations with extensive laboratory practice. Students will explore Optical Microscopy (OM), Optical Interferometry (OI), Optical Coherence Tomography (OCT), and Fourier Transform Infrared (FTIR) Spectroscopy, gaining familiarity with diverse optical instruments and their applications. Emphasis is placed on component identification, optical alignment, custom design, and prototype construction on optical breadboards. Learners will develop critical skills in image acquisition, quantitative analysis, and interpretation, while also mastering interferometric methods to measure wavelength, coherence length, and fringe visibility. Each module is structured to integrate hands on experiments with conceptual learning, ensuring a strong balance between theory and practice.

Laboratory sessions reinforce these outcomes through practical exercises such as microscope assembly, prototype design with Kohler illumination, OCT system alignment and A line acquisition, and FTIR spectrometer construction with interferogram processing. Students will characterize instrument performance in terms of resolution, magnification, sensitivity, and spectral precision, while applying computational tools like MATLAB and Python for data analysis. By the end of the course, participants will be equipped to design, build, and evaluate optical systems, interpret complex imaging and spectral data, and apply these methods to real world challenges in materials science, biomedical imaging, and environmental research.

Sai Siva Gorthi , Jaya Prakash , Tapajyoti Das Gupta , Manukumara Manjappa

Pre-requistes :

References :

1. Optical Design of Microscopes by George H. Seward, SPIE Press
2. "Fundamentals of Optics" by Jenkins and White, McGraw Hill Eductation

Mathematics

Preface

MA 201 (JAN) 7 : 0

Project

Subhojoy Gupta

Pre-requistes : None

References : None

MA 218 (JAN) 3 : 0

Number Theory

Shaunak Vilas Deo

Pre-requistes : None

References : None

MA 219 (AUG) 3 : 1

Linear Algebra

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

Apoorva Khare

Pre-requistes : None

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.

MA 220 (JAN) 3 : 0

Representation theory of Finite groups

Representation of finite groups, irreducible representations, complete reducibility, Schur's lemma, characters, orthogonality, class functions, regular representations and induced representation, the group algebra. Linear groups: Representation of the group SU2 Books Aritin, M., Algebra, Prentice Hall of India, 1994. Fulton W., and Harris, J., Representation Theory,Spinger-Verlag, 1991. Serre, J.P., Linear Representations of Finite Groups,Springer-Verlag, 1977.

Venkatesh R

Pre-requistes : None

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

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.

Swarnendu Sil

Pre-requistes : None

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.

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).

Gautam Bharali

Pre-requistes : None

References : None

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.

Siddhartha Gadgil

Pre-requistes : None

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 and singular holology: Simplicial complexes, chain complexes, definitions of the simplicial and singular homology groups, properties of homology groups, applications.

Harish Seshadri

Pre-requistes : None

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.

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

Vamsi Pritham Pingali

Pre-requistes : None

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

MA 242 (AUG) 3 : 0

Partial Differential Equations

Arka Mallick

Pre-requistes : None

References : Garabedian, P.R.,Partial Differential Equations, John Wiley and Sons, 1964. ~Fritz John, Partial Differential Equations, Springe (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.

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, theory of estimation, testing of hypotheses, linear models.

Manjunath Krishnapur

Pre-requistes : None

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 305 (JAN) 3 : 0

Analysis on Lie Groups

Muna Naik

Pre-requistes : None

References : None

MA 312 (AUG) 3 : 0

Commutative Algebra

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

Bharathwaj Palvannan

Pre-requistes : None

References : None

MA 313 (AUG) 3 : 0

Algebraic Number Theory

Number fields and rings of integers, Dedekind domains; prime factorization, ideal class group, finiteness of class number, Dirichlet ’s unit theorem, cyclotomic fields, theory of valuations, local fields.

Radhika Ganapathy

Pre-requistes : None

References : Jurgen Neukirch, Algebraic Number theory, Springer, 1999~Daniel A. Marcus,Number fields, Springer Universitext, 2018~J.P Serre, Local fields, Springer GTM 67, 1979

MA 315 (AUG) 3 : 0

Lie Algebra and Their Representation

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

Venkatesh R

Pre-requistes : None

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

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.

Nandakumaran A K , Subhojoy Gupta

Pre-requistes : None

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 326 (JAN) 3 : 0

Fourier Analysis

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

Narayanan E K

Pre-requistes : None

References : None

MA 333 (AUG) 3 : 0

Riemannian Geometry

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

Ved V Datar

Pre-requistes : None

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

MA 339 (AUG) 3 : 0

Geometric Analysis

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

Vamsi Pritham Pingali

Pre-requistes : None

References : Do Carmo, Riemannian Geometry.~Griffiths and Harris, Principles of Algebraic Geometry.~S. Donaldson, Lecture Notes for TCC Course "Geometric Analysis".~J.Kazdan, Applications of Partial Differential Equations To Problems in Geometry. ~L. Nicolaescu, Lectures on the Geometry of Manifolds.~T. Aubin, Some nonlinear problems in geometry.~C. Evans, Partial differential equations. ~Gilbarg

MA 340 (JAN) 3 : 0

Advanced Functional Analysis

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

Narayanan E K

Pre-requistes : None

References : None

MA 341 (AUG) 3 : 0

Matrix Analysis and Positivity

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

Apoorva Khare

Pre-requistes : None

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

MA 350 (JAN) 3 : 0

Analytic Number Theory

Soumya Das

Pre-requistes : None

References : None

MA 361 (AUG) 3 : 0

Probability theory

Discrete parameter martingales: Conditional expectation. Optional sampling theorems. Doob's inequalities. Martingale convergence theorems. Applications.Brownian motion. Construction. Continuity properties. Markov and strong Markov property and applications. Donsker's invariance principle. Further sample path properties.Ergodic theory (if time permits) Probability measures and random variables, pi and lambda systems, expectation,the moment generating function, the characteristic function,laws of large numbers, limit theorems, conditional contribution and expectation, martingales, infinitely divisible laws and stable laws.

Srikanth Krishnan Iyer

Pre-requistes : None

References : Rick Durrett, Probability:theory and examples., Cambridge University Press,2010~David Williams, Probability with Martingales, Cambridge Univ., Press,1991~Peter Mörters and Yuval Peres, Brownian motion, Cambridge University Press, 2010~Olav Kallenberg, Foundations of modern Probability. Second Edition, Springer-Verlag, 2002~John Walsh, Knowing the Odds: An Introduction to

MA 362 (JAN) 3 : 0

Stochastic Processes

Construction and sample path properties of Brownian motion. Strong Markov property. Martingales in Brownian motion. Long term behaviour. Skorokhod embedding and Donsker's theorem. Stochastic calculus. Ito's formula. Introduction to diffusions.

Manjunath Krishnapur

Pre-requistes : MA 361

References : 1. J.-F. Le Gall, Brownian Motion, Martingales, and Stochastic Calculus, Springer (2016).

2. Morters and Peres, Brownian motion, Cambridge university press (2012).

MA 380 (AUG) 3 : 0

Introduction to Complex Dynamics

Gautam Bharali

Pre-requistes : None

References : None

MA 394 (JAN) 3 : 0

Techniques in discrete probability

We shall illustrate some important techniques in studying discrete random structures through a number of examples. The techniques we shall focus on will include (if time permits) the probabilistic method; first and second moment methods, martingale techniques for concentration inequalities; coupling techniques, monotone coupling and censoring techniques; correlation inequalities, FKG and BK inequalities; isoperimetric inequalities, spectral gap, Poincare inequality; Fourier analysis on hypercube, Hypercontractivity,noise sensitivity and sharp threshold phenomenon; Stein's method; entropy and information theoretic techniques. We shall discuss applications of these techniques in various fields such as Markov chains, percolation, interacting particle systems and random graphs.

Manjunath Krishnapur

Pre-requistes : None

References : None

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.

Narayanan E K

Pre-requistes : None

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.

Shaunak Vilas Deo

Pre-requistes : None

References : Artin M. Algebra. Prentice-Hall of India. 1994.~Dummit. D. S. and Foote R. M.cAbstract Algebra. McGraw-Hill. 1986.~Herstein I. N. Topics in Algebra. JohncWiley and Sons. 1995.~Lang S. Algebra. (3rd Ed.) Springer. 2002.

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

Venkatesh R

Pre-requistes : None

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

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.

Thirupathi Gudi

Pre-requistes : None

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 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.

Harish Seshadri

Pre-requistes : None

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.

MA 235 (JAN) 3 : 0

Introduction to differentiable manifolds

A review of continuity and differentiability in more than one variable. The inverse, implicit, and constant rank theorems. Definitions and examples of manifolds, maps between manifolds, regular and critical values, partition of unity, Sard's theorem and applications. Tangent spaces and the tangent/cotangent bundles, definition of general vector bundles, vector fields and flows, Frobenius' theorem. Tensors, differential forms, Lie derivative and the exterior derivative, integration on manifolds, Stokes' theorem. Introduction to de Rham cohomology.

Subhojoy Gupta

Pre-requistes :

References : 1. Tu, Loren An Introduction to Manifolds, Universitext, Springer-Verlag 2011. 2. John Lee, Introduction to Smooth Manifolds, Graduate Texts in Mathematics 218, Springer-Verlag 2012. 3. Barden, Dennis and Thomas, Charles, An Introduction to Differential Manifolds, World Scientific 2003. 4. Spivak, Michael Comprehensive Introduction to Differential Geometry, Vol 1, Publish or Perish, 2005.

MA 262 (JAN) 3 : 0

Introduction to Stochastic Processes

Discrete parameter Markov Chains: Chapman-Kolmogorov equations, Classification of states, Limit Theorems, Examples: Random Walks, Gambler's Ruin, Branching processes. Time reversible Markov chains. Simulations and MCMC; Poisson processes: Definitions, and properties: interarrival and waiting time distributions, superposition and thinning, Nonhomogeneous Poisson process, Compound Poisson process. Simulation; Continuous time Markov Chains: Definition, Birth-Death processes, Kolmogorov backward and forward equations, Limiting probabilities, Time reversibility. Queueing Theory, Simulation; Renewal Theory; Brownian Motion.

Arvind Ayyer

Pre-requistes :

References : Samuel Karlin and Howard M. Taylor: A first course in Stochastic Processes, 2nd edition, Academic Press, 1975. Sheldon M. Ross:Stochastic Processes, 2nd edition, John Wiley and Sons, 2008. Rabi N. Bhattacharya and Edward C. Waymire: Stochastic Processes and Applications, Siam, 2009.

MA 379 (JAN) 3 : 0

Linear Algebraic Groups

Syllabus: Basic notions of linear algebraic groups (connected components, orbits, Jordan decomposition), Lie algebras, algebraic tori, solvable and unipotent groups, parabolic and Borel subgroups, representations of linear algebraic groups, reductive and semi-simple groups, the Weyl group, root systems and root datum, classification of connected reductive groups over an algebraically closed field.

Radhika Ganapathy

Pre-requistes :
1. Commutative algebra

References : 1. T. A. Springer, Linear Algebraic Groups, Modern Birkhaeuser Classics, 2nd edition, 1998.
2. Armand Borel, Linear Algebraic Groups, GTM 126, 2nd edition, 1991.
3. James Humphreys, Linear Algebraic Groups, GTM 21, 1975.

MA 389A (AUG) 1 : 0

Seminar on topics in mathematics I

The students must commit to attending a seminar series (algebra, eigenfunctions, etc) of their choice and attend all the talks during the semester.

Vamsi Pritham Pingali

Pre-requistes : None

References : No references.

MA 389B (JAN) 1 : 0

Seminar on topics in mathematics II

The students must commit to attending a seminar series (algebra, eigenfunctions, etc) of their choice and attend all the talks during the semester.

Vamsi Pritham Pingali

Pre-requistes : None

References : No references.

MA 237 (JAN) 3 : 0

Introduction to Tilings

This course will be an introduction to the mathematical theory of tilings. The first part of the course will concern tilings of the Euclidean plane, and topics covered will include tilings by regular Euclidean polygons, Archimedean tilings, symmetry groups of planar tilings, substitution tilings, aperiodic tilings including the Penrose tiles and the hat tile. The second part of the course will concern tilings of the hyperbolic plane, including triangle groups, existence of weakly aperiodic tiles and semi-regular tilings. In the final part of the course, topics related to tilings on surfaces, conformal tilings, and higher-dimensional tilings (in Euclidean n-space and hyperbolic 3-space) will be discussed. Along the way, the course will cover the basic notions needed from Euclidean and hyperbolic geometry, group theory, topology, and the theory of Riemann surfaces.

Subhojoy Gupta

Pre-requistes :

Prerequisites for undergraduates: MA 231 (Topology)

References : Suggested books: “The Tiling Book” by Colin Adams, published by the American Mathematical Society (2022). “Tilings and Patterns” by Grünbaum and Shephard, published by W.H. Freeman and Company (1987).

MA 347A (JAN) 3 : 1

Topics in Finite Element Methods

Weak derivative, Sobolev spaces. Triangulation, finite element construction, interpolation estimates. Conforming finite elements, non-conforming finite elements, mixed methods, discontinuous Galerkin methods and polygonal mesh methods for solving PDEs. Solving time dependent PDEs by using finite differences in time and finite elements in space. Lab component consisting of MATLAB implementation of these methods.

Thirupathi Gudi

Pre-requistes :
UM101, UM102, UM204. Topics from MA 222, MA 223 and MA 242 are

References : 1. C. Johnson. Numerical Solution of Partial Differential Equations by the Finite Element Method, Dover Publications, New York, 2009
2. Alexandre Ern and J.-L. Guermond, Theory and Practice of Finite Elements, vol. 159 of Applied Mathematical Series, Springer, New York, 2004
3. J. N. Reddy, An introduction to the Finite Element Method, McGraw-Hill, Inc., 1993.

MA 222A (JAN) 3 : 0

Topics in Measure Theory

The aim is to treat certain topics which are just a tad too advanced to be included in a first course in measure and integration theory, but are not too specialized and are useful to analysts in general.
Main Topics:
1. Fourier Transform: Riemann- Lebesgue lemma, L^2 theory.
2. Convergence in Measure.
3. Riesz Representation Theorem.
4. Functions of Bounded Variations; Fundamental Theorem of Calculus for absolutely continuous functions.
5. Hausdorff Measures, Isodiametric Inequality.
6. Area, Co-area Formulas.

Arka Mallick

Pre-requistes :
MA 219, MA 200, MA 222.
The course MA 235 might also be useful, but
References : 1. Measure Theory and Fine Properties of Functions by Lawrence Craig Evans and Ronald F. Gariepy.
2. Sets of Finite Perimeter and Geometric Variational Problems: An Introduction to Geometric Measure Theory by Francesco Maggi.
3. Lectures on Analysis on Metric Spaces by Juha Heinonen.

MA 319A (AUG) 3 : 0

Schubert calculus

This course will provide an elementary introduction to the combinatorial aspects of Schubert calculus, the part of enumerative geometry dealing with classical varieties such as Grassmanians, flag varieties, and their Schubert varieties.

Topics include Grassmann-Plucker relations, Schubert cells, Pieri's formula, Young tableaux, Schur polynomials, Jacobi-Trudi and Giambelli's formulas, Littlewood-Richardson rule, Gelfand-Serganova cells and matroids, Bruhat order, Chevalley-Monk's formula, Schubert polynomials

Arvind Ayyer

Pre-requistes :

We will assume a basic background in linear algebra and
References : W.Fulton, Young tableaux, Cambridge University Press, 1997.

L.Manivel, Symmetric functions, Schubert polynomials and degeneracy

MA 374A (JAN) 3 : 0

Regularity in the Calculus of Variations

Dirichlet integral and p-Dirichlet integral: Sobolev spaces, existence of minimizers, weak form of the Euler-Lagrange equations.
• Linear Regularity: L^2 estimate, Schauder estimates, L^p estimates
• DeGiorgi-Nash-Moser theory: Moser iteration, Harnack inequality, DeGiorgi’s solution of Hilbert’s 19th problem.
• Regularity of p-Laplacian: C^{1,\alpha} regularity and Uhlenbeck structure.

Swarnendu Sil

Pre-requistes :
MA 221, MA 222, MA 223

References : 1)Giaquinta, M., and Martinazzi, L. An introduction to the regularity theory for elliptic systems, harmonic maps and minimal graphs, second ed., vol. 11 of Appunti. Scuola Normale Superiore di Pisa (Nuova Serie) [Lecture Notes. Scuola Normale Superiore di Pisa (New Series)]. Edizioni della Normale, Pisa, 2012.

MA 207 (JAN) 0 : 1

Proofs Lab with Lean Prover

The goal of this course is to help students learn to write rigorous mathematical proofs, with the Lean Prover used as a tool via its controlled natural language library Verbose Lean. The course will consist of a weekly lab session where students work out exercises where they write formal proofs in Lean and then rewrite these as informal proofs to be read by a person.

List of Topics:

* Writing proofs guided by proof assistants: Goal states, using tactics to make progress, understanding errors and deadends.
* Writing proofs based on calculations.
* Logic in statements and proofs: implication and hypothesis, combining with “and”, “or” and “not”.
* Universal quantification and Hypothesis
* Existential quantification: supplying terms that work, understanding dead ends from incorrect terms.
* Proof in Analysis written rigorously, e.g. uniqueness of limits of sequences.
* Proofs of an Algebraic nature written rigorously: e.g. properties of divisibility.

Siddhartha Gadgil

Pre-requistes : None

References : * The Lean language: https://lean-lang.org/
* Verbose Lean: https://github.com/PatrickMassot/verbose-lean4
* Exercises in Verbose Lean: https://github.com/PatrickMassot/proofs_with_lean

MA 366A (JAN) 3 : 0

Introduction to Stochastic Finance

Financial market. Financial instruments: bonds, stocks, derivatives. Discrete Time Models: Single and multi-period Binomial no-arbitrage pricing model, Martingale methods for pricing. Interest rate-dependent assets: binomial models for interest rates, fixed income derivatives, forward measure and future. Capital asset pricing model (CAPM). Continuous time Models: geometric Brownian motion and Ito calculus. Option pricing and hedging in continuous time: Black-Scholes theory, risk-neutral pricing, fundamental theorem of asset pricing, Feynman-Kac formula and connections to partial differential equations, term-structure models, option pricing in incomplete markets: Merton's jump diffusion and Heston's models.

Srikanth Krishnan Iyer

Pre-requistes :
It is desirable to have taken MA 262 Introduction to Stochastic Processes and MA 361 Probability Theory or equivalent. Students who

References : 1. Shreve, S.E., Stochastic Calculus for Finance I: The Binomial Asset Pricing Model, Springer, 2005.
2. Shreve, S.E., Stochastic Calculus for Finance II: Continuous-Time Models, Springer, 2004.
3. Shiryaev, A.N., Essentials of Stochastic Finance, World Scientific, 1999.

Physics

Preface

HE 215 (AUG) 3 : 0

Nuclear and Particle Physics

Radioactive decay, subnuclear particles. Binding energies. Nuclear forces,pion exchange, Yukawa potential. Isospin, neutron and prot on.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 , Jyothsna Rani Komaragiri

Pre-requistes : None

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

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.

Baladitya Suri

Pre-requistes : None

References :

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.

Shibananda Das

Pre-requistes : None

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 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. Three dimensional problems. Rotations, angular momentum operators, commutation relations. Spherical harmonics. Hydrogen atom, its spectrum and wave functions. Symmetries and degeneracies. Spin angular momentum. Spin-1/2 and two-level systems. Addition of angular momentum. Spin-orbit and hyperfine interactions. Time-independent perturbation theory. Stark and Zeeman effects. Variational methods, ground state of helium atom.

Banibrata Mukhopadhyay

Pre-requistes : None

References : None

PH 204 (JAN) 3 : 0

Quantum Mechanics II

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

Biplob Bhattacherjee

Pre-requistes : None

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 205 (AUG) 3 : 0

Math Methods of Physics

Justin Raj David

Pre-requistes : None

References : 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

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.

Tanmoy Das

Pre-requistes : None

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.

Shubhadeep Biswas

Pre-requistes : None

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

PH 208 (JAN) 3 : 0

Condensed Matter Physics-I

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

Aveek Bid

Pre-requistes : None

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

PH 211 (AUG) 0 : 3

General Physics Laboratory

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

Srimanta Middey , Tapajyoti Das Gupta

Pre-requistes : None

References : None

PH 212 (JAN) 0 : 3

Experiments in Condensed Matter Physics

Stirling Engine Thinfilm deposition by thermal evaporation technique Low temperature measurement (using closed cycle Helium cryostat) Scanning Tunneling Microscopy Atomic Force Microscopy Franck-Hertz Experiment Laue Pattern of Single Crystal Semiconductor Thermogenerator (Peltier and Seebeck effect) Alpha Scattering Lock-in Amplifier

Vibhor Singh

Pre-requistes : None

References : None

PH 213 (AUG) 0 : 4

Advanced Experiments in Condensed Matter Physics

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

Anil Kumar P S

Pre-requistes : None

References : None

PH 215 (AUG) 3 : 0

Nuclear and Particle Physics

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

Jyothsna Rani Komaragiri

Pre-requistes : None

References : None

PH 217 (AUG) 3 : 0

Fundamentals of Astrophysics

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

Tarun Deep Saini

Pre-requistes : None

References : None

PH 250A (JAN) 0 : 6

Project I

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

Prateek Sharma

Pre-requistes : None

References : None

PH 320 (AUG) 3 : 0

Condensed Matter Physics - II

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

Sumilan Banerjee

Pre-requistes : None

References : None

PH 322 (JAN) 3 : 0

Molecular Simulation

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

Sudeep Neelakantan Punnathanam , Anand Srivastava

Pre-requistes : None

References : None

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.

Vijay B Shenoy

Pre-requistes : None

References : None

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.

Anil Kumar P S , Akshay Singh

Pre-requistes : None

References : None

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.

Anindya Das

Pre-requistes : None

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

Pre-requistes : None

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

PH 359 (JAN) 3 : 0

Physics at the Nanoscale

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

Arindam Ghosh

Pre-requistes : None

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

PH 360 (AUG) 3 : 0

Biological Physics

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

Sumantra Sarkar

Pre-requistes : None

References : None

PH 364 (JAN) 3 : 0

Topological Phases of Matter (Theory and experiment)

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

Subroto Mukerjee

Pre-requistes : None

References : None

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.

Tarun Deep Saini

Pre-requistes : None

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

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

Pre-requistes : None

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) 0 : 2

Astronomical Techniques (Seminar Course)

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

Rajeev Kumar Jain

Pre-requistes : None

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 M easurement (2nd ed), Wiley, NY N.Tsoulfanidis, Measurement and Detection of Radiation (2nd ed), Taylor &Francis, Washington DC

PH 380 (JAN) 3 : 0

Non-equilibrium Quantum Many-Body Dynamics

Basic notions of quantum dynamics. Thermalization and quantum statistical mechanics – eigenstate thermalization hypothesis (ETH), entanglement and quantum information, transport, and quantum chaos. Analytical and numerical methods of many-body quantum dynamics – Schwinger-Keldysh field theory for closed and open systems in out-of-equilibrium and non-equilibrium steady states, quantum kinetic equations, Wigner function, and semiclassical approximations, effective field theories, exact diagonalization, matrix-product state methods. Topics in quantum many-body dynamics – dynamical phase transitions, many-body localization, entanglement transitions, dynamics of integrable and non-integrable systems, quantum quenches, Floquet theory, and time crystals.

Sumilan Banerjee

Pre-requistes : Quantum Mechanics I & II, Statistical Mechanics, Condensed Matter Physics

References : 1. A. Kamenev, Field Theory of Non-Equilibrium Systems (Second Edition), Cambridge, 2023. 2. A. Altland and B. Simons, Condensed Matter Field Theory (Second Edition), Cambridge, 2010.

PH 367 (JAN) 3 : 0

Plasma Physics and Applications

What is a plasma? Plasma Parameters; approaches to Plasma Physics [3 hours] Debye length, the plasma parameter, Saha Ionization equation Magnetohydrodynamics, two-fluid, (anisotropic) transport coefficients, kinetic approach (qualitative) Single particle dynamics: [3 hours] Uniform E and B Fields: E=0, Finite E, Gravitational Field Nonuniform B Field: Grad B drift, Curvature drift, Magnetic Mirrors Nonuniform Field : Nonuniform E field, Time-Varying E and B Field Adiabatic Invariants: The first adiabatic invariant, Second Adiabatic invariant and Third adiabatic invariant Examples from fusion (mirror machines), space (van Allen belts, particle drifts) Waves in plasmas: [9 hours] Representation of Waves, Plasma Oscillation, Electron Plasma Waves, Sound waves, Electrostatic ion and electron oscillation perpendicular to B, electromagnetic waves perpendicular to B, cut-off and resonances, hydromagnetic and magnetosonic waves. Application examples: Faraday rotation, pulsar dispersion Diffusion and resistivity: [5 hours] Diffusion and Mobility in Weakly Ionized Gases, Decay of a Plasma by Diffusion, Diffusion Across a Magnetic Field, Collisions in Fully Ionized Plasmas, Bohm Diffusion and Neoclassical Diffusion. Kinetic theory of plasma: [9 hours] The Vlasov-Maxwell equation, The evolution of distribution function, Integrating along the unperturbed orbits, The dielectric tensor, The hot plasma dispersion relation, and Electrostatic waves. Landau damping. Nonlinear effects in plasmas: [6 hours] Ponderomotive force, parametric instabilities, instability threshold, nonlinear Landau damping. Turbulence. Basic paradigms & applications: [4 hours] plasma sheath, turbulence reconnection, dynamo, cosmic ray acceleration Fusion energy: [6 hours] Magnetic fusion, tokamak, stellarator, Inertial fusion.

Animesh Kuley

Pre-requistes :
PH202 (Statistical Mechanics), PH 206 (Electromagnetic Theory)

References : 1. Fundamentals of Plasma Physics, by J. A. Bittencourt 2. Introduction to Plasma Physics and Controlled Fusion, by F F Chen 3. Plasma Kinetic Theory, by Donald Gary Swanson Tokamaks, by John Wesson 4. Plasma Physics for Astrophysics, by Kulsrud 5. Introduction to Plasma Physics: With space and laboratory applications, by Gurnett & Bhattacharjee 6. The Physics of Fluids and Plasmas:

PH 373 (AUG) 3 : 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.

Prantika Bhowmik

Pre-requistes :
None

References : [1] Acheson: Elementary Fluid Dynamics [2] R. Blandford & K. Thorne: Application of Classical Physics [3] F. F. Chen: Introduction to Plasma Physics and Controlled Fusion [4] A. Rai Choudhuri: The Physics of Fluids and Plasmas [5] P. G. Drain & W. H. Reid: Hydrodynamic stability [6] R. Kulsrud: Plasma Physics for Astrophysics [7] Landau & Lifshitz: Fluid Mechanics

PH 372 (AUG) 3 : 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.

Prantika Bhowmik

Pre-requistes :

None

References : G. Rybicki & A. Lightman: Radiative Processes in Astrophysics

PH 301 (AUG) 2 : 0

Seminar Course

We wish to enhance the credit for the seminar course. Under the updated seminar course, we will make it compulsory for all the students taking this course to attend all department colloquia and to give a presentation and a write-up based on one of the topics covered in the colloquiua. Also, we plan to include a few lectures on topics such as Research Ethics and Tools for Research. With changes the removal of the workshop course, the total credits in compulsory courses for IPhD students remain the same.

Akshay Singh

Pre-requistes : None

References : None

Instrumentation and Applied Physics_QT

Preface

QT 207 (AUG) 3 : 0

Introduction to Quantum Computation

Axiomatic quantum theory; Quantum states, observables, measurement and evolution; Qubits versus classical bits; Spin-half systems and photon polarizations; Pure and mixed states; Density matrices; Quantum correlations; Entanglement and Bell's theorems; Turing machines and computational complexity; Reversible computation; Universal quantum logic gates and circuits; Quantum algorithms; Database search; Fast Fourier Transform and prime factorisation.

Chandrashekar C M

Pre-requistes : None

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

QT 209 (AUG) 3 : 0

Introduction to Quantum Communications and Cryptography

Digital communication; Communication channels; Information and entropy; Shannon's theorems; Quantum communication, dense coding and teleportation; von Neumann entropy and quantum channel capacity; General quantum evolution and superoperators; Errors and error correction codes; Stabilizer formalism; Cryptography and one-time pad; Public and private key cryptography; Quantum key distribution; Quantum cryptography. Geometrical and wave optics; Quantisation of the electromagnetic field; Photon number states; Coherent states; Squeezing and beam-splitters.

Sanjit Chatterjee , Varun Raghunathan , Manukumara Manjappa

Pre-requistes : None

References : Nielsen M.A. and Chuang I.L., Quantum Computation and Quantum Information, Cambridge University Press, 2000. Preskill J., Lecture No tes for the Course on Quantum Computation, http://www.theory.caltech.edu/people/preskill/ph229

QT 211 (AUG) 1 : 2

Basic Quantum Technology Laboratory

Intro to RF equipment – VNA, signal generators, AWGs,Oscilloscopes, Basics of Microwave Engineering – Impedance,S-parameters, Charac terisation of passive RF components – Cables, terminations,attenuators, directional couplers, RF mixer, filters, circulators and isolators, Python packages from Quantum Optics and Quantum computation – QISKIT and QuTiP, Simulating basic quantum Hamiltonians,Dissipative systems, Quantum circuit simulations.

Vibhor Singh

Pre-requistes : None

References : 1. David Pozar, Microwave Engineering 2. QISKIT and QuTiP programming manual

QT 204 (JAN) 3 : 0

Introduction to Materials for Quantum Technologies

Recap of basic solid-state physics: Electronic band structure; Phonon- band structure, electron-phonon interactions, electron transport and modeling in nanoscopic devices Topology and Quantum Devices: Semiconductor heterostructures, Two dimensional electron systems, Topological materials, Introduction to Superconductivity Correlations and disorder: Electron-electron interactions, Peierls distortion and transition,Disorder physics,Anderson’s localization, Quantum devices through correlations,Magnetic materials, Dielectric materials and ferroelectrics, phase transitions Optics and optical materials: Light-Matter Interaction,introduction to nonlinear optical materials, Optical properties of semiconductors and metals,properties of nanostructured materials, plasmonics.

Srimanta Middey , Dhavala Suri

Pre-requistes :

References : Solid State Physics by N. Aschcroft and N. D. Mermin Electrons and Phonons: The Theory of Transport Phenomena in Solids by J.Ziman Electronic Processes in Non-Crystalline Materials by N. F.Mott and E. A. Davi.

QT 299 (JAN) 0 : 20

Project

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. Project

Baladitya Suri

Pre-requistes : None

References : Quantum Measurement by Braginsky and Khalili Quantum measurement by Wiseman and Milburn Mechanics by Landau-Lifshitz.

QT 202 (JAN) 3 : 0

Introduction to Quantum Measurement

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.

Baladitya Suri

Pre-requistes :

References : Quantum Measurement by Braginsky and Khalili Quantum measurement by Wiseman and Milburn Mechanics by Landau-Lifshitz.

Mathematical Science_Int PhD

Preface

IISc's Knowledge and E-Learning Network

Preface

IISc's Knowledge and E-Learning Network

Artificial Intelligence Stream

Preface

E0 270o (JAN) 3 : 1

Machine Learning

Ambedkar Dukkipati

Pre-requistes : None

References : None

E9 241o (AUG) 3 : 1

Digital Image Processing

Chandra Sekhar Seelamantula

Pre-requistes : None

References : None

E0 251o (JAN) 3 : 1

Data Structures and Graph Analytics

Chandramani Kishore Singh

Pre-requistes : None

References : None

E1 277o (AUG) 3 : 1

Reinforcement Learning

Introduction to Reinforcement Learning, Multi-armed bandits, Markov decision processes, Dynamic Programming - Value and Policy Iteration Methods, Model-Free Learning Approaches, Monte-Carlo Methods, Temporal Difference Learning, Q-learning, SARSA, Double Q-learning, Value Function Approximation Methods - TD Learning with Linear Function Approximation, Neural Network Architectures, Deep Q-Network Algorithm, Policy Gradient Methods, Actor-Critic Algorithms.

Shalabh Bhatnagar

Pre-requistes :

References : 1. R. Sutton and A. Barto, Reinforcement Learning, MIT Press, 2'nd Ed., 2018 2. D.Bertsekas, Reinforcement Learning and Optimal Control, Athena Scientific, 2019 3. Selected Recent Papers

DS 265o (AUG) 3 : 1

Deep Learning for Visual Analytics

Basics of machine learning and computer vision, CNN basics, Loss function and back propagation, Object Recognition, Detection and Segmentation. Recurrent Neural Networks, LSTM, Generative Adversarial Networks (GANs), Self-supervised learning, Transformers, Explainable AI, Adversarial Robustness of Deep models.

Venkatesh Babu R

Pre-requistes :

Basics knowledge of Machine learning and Image processing.

References : 1. Dive into Deep learning, Aston Zhang, Zachary C. Lipton, Mu Li, and Alexander J. Smola (Online) 2. Recent Research papers.

AI 299o (AUG) 0 : 27

MTech Dissertation Project

Chandramani Kishore Singh

Pre-requistes : None

References : None

E1 252o (JAN) 3 : 1

Linear and Nonlinear Optimization

Chandramani Kishore Singh

Pre-requistes : None

References : None

E1 294o (JAN) 3 : 1

Edge and Cloud Systems for Machine Learning Algori

Sumit Kumar Mandal

Pre-requistes : None

References : None

E1 315o (JAN) 3 : 1

Deep Learning for Robotics

Shishir Nadubettu Yadukumar , Pushpak Jagtap , Ravi Prakash

Pre-requistes : None

References : None

Data Science & Business Analytics Stream

Preface

DA 231o (AUG) 3 : 1

Data Engineering at Scale

Yogesh L Simmhan

Pre-requistes : None

References : None

DA 226o (AUG) 3 : 1

Financial Analytics

Shashi Jain

Pre-requistes : None

References : None

DA 227o (AUG) 3 : 1

Data Mining

Parthasarathy Ramachandran

Pre-requistes : None

References : None

DA 218o (JAN) 3 : 1

Probabilistic Machine Learning: Theory and Applica

Punit Rathore

Pre-requistes : None

References : None

DA 299o (AUG) 0 : 32

DSBA Stream Project

Deepak Narayanan Subramani

Pre-requistes : None

References : None

DA 216o (JAN) 3 : 1

Applied Artificial Intelligence in Healthcare

Vaanathi Sundaresan

Pre-requistes : None

References : None

DS 285o (JAN) 3 : 1

Tensor Computations for Data Science

Ratikanta Behera

Pre-requistes : None

References : None

DA 219o (JAN) 3 : 1

Quantum Computing Methods: Theory and Applications

Phani Sudheer Motamarri

Pre-requistes : None

References : None

DA 204o (AUG) 3 : 1

Data Science in Practice

Pandarasamy Arjunan

Pre-requistes : None

References : None

DA 245o (AUG) 3 : 1

Linear Optimization and Network Science

Tarun Rambha

Pre-requistes : None

References : None

Electronics & Communication Engg. Stream

Preface

E2 202o (AUG) 3 : 1

Random Process

Parimal Parag

Pre-requistes : None

References : None

E2 201o (JAN) 3 : 1

Digital Communications

Chandra R Murthy

Pre-requistes : None

References : None

E1 245o (JAN) 3 : 1

Statistical Inference for Engineers and Data Scientists

Vaibhav Katewa

Pre-requistes : None

References : None

E1 220o (AUG) 3 : 1

Linear Algebra

Sundeep Prabhakar Chepuri

Pre-requistes : None

References : None

E2 299o (AUG) 0 : 28

MTech(Online) ECE Stream Project

Debdeep Sarkar

Pre-requistes : None

References : None

E8 205o (JAN) 3 : 1

Antennas and Circuits for Emerging Communication a

Debdeep Sarkar

Pre-requistes : None

References : None