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 in Engineering or a Master's degree in Science, the RTP consists of a minimum of 24 credits. Similar RTP requirements apply for students who upgrade or continue their registration from the 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

IISc's Knowledge and E-Learning Network

Artificial Intelligence Stream

Preface

E9 241o (AUG) 3 : 1

Digital Image Processing

Chandra Sekhar Seelamantula

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

E0 295o (AUG) 0 : 0

Introduction to Cryptography (Online)

Bhavana Kanukurthi , Chaya Ganesh

Pre-requistes : None

References : None

E1 286o (AUG) 3 : 1

Deep Generative Models

Prathosh A.P

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 , Shashi Jain

Pre-requistes : None

References : None

DS 261o (AUG) 3 : 1

Artificial Intelligence for Medical Image Analysis

Phaneendra Kumar Yalavarthy

Pre-requistes : None

References : None

DA 299o (MAY) 0 : 32

DSBA Stream Project

Pre-requistes : None

References : None

DA 204o (AUG) 3 : 1

Data Science in Practice

Pandarasamy Arjunan

Pre-requistes : None

References : None

Electronics & Communication Engg. Stream

Preface

E2 202o (AUG) 3 : 1

Random Process

Aditya Gopalan

Pre-requistes : None

References : None

E2 251o (MAY) 3 : 1

Communication Systems Design

Pre-requistes : None

References : None

E1 220o (AUG) 3 : 1

Linear Algebra

Sundeep Prabhakar Chepuri

Pre-requistes : None

References : None

E2 299o (MAY) 0 : 28

MTech(Online) ECE Stream Project

Sundeep Prabhakar Chepuri

Pre-requistes : None

References : None

E9 246o (AUG) 3 : 1

Advanced Topics in Image Processing

Soma Biswas

Pre-requistes : None

References : None

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 225 (AUG) 0 : 6

Project - II

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.

Sekar K,Supratim Ray,Shantanu P Shukla

Pre-requisites : None

References : None

DB 250 (AUG) 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 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.

Ganesh Nagaraju , Debabrata Laha

Pre-requistes : None

References : None

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

Pre-requistes : None

References : None

Ecological Sciences

Preface

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.

Rohini Balakrishnan , Kavita Isvaran

Pre-requistes : None

References :
Alcock,J.,Animal Behaviour - An Evolutionary Approach (Sixth Edition),Sinauer Associates,1998~Neuroethology – J. M. Camhi (1984)

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

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 309A (AUG) 3 : 0

Ecosystems and Global Change

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

Sumanta Bagchi

Pre-requistes :
No specific pre-requisites

References : Schlesinger WH, and E Bernhardt (2013). Biogeochemistry: An analysis of global change. 3rd ed, 688 pp. Academic Press. ISBN 9780123858740.
Chapin FS, PA Matson, and P Vitousek (2011). Principles of terrestrial ecosystem ecology. 2nd ed, 529 pp. Springer. ISBN

Neuroscience

Preface

NS 201 (AUG) 2 : 0

Systems Neuroscience

Neuronal biophysics, sensation & perception, motor systems

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 , Srikanth Padmala

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.

Pre-requistes : None

References : None

NS 302 (JAN) 2 : 0

Topics in Molecular and Cellular Neuroscience

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

Pre-requistes : None

References : None

Microbiology and Cell Biology

Preface

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

Pre-requistes : None

References :

"Stanier, R.V.,Adelberg E.A and Ingraham J.L., GENERAL

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

MC 207 (AUG) 3 : 0

Molecular and Cellular Biology

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

Umesh Varshney

Pre-requistes : None

References :
Lewin's Genes X, Lewin,B.,Krebs,J.E.

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 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

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.~

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 : None

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.

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 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 :

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).

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.

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; chromosome mutations: variation in number and arrangement, Extranuclear inheritance, Gene mutation, DNA-repair and Transposition.

Epigenetics: Overview and concepts, Genomic imprinting, Dosage compensation; X-chromosome inactivation, DNA/RNA methylation and histone modifications, Linking RNA to chromatin, Gene regulation by Polycomb and Trithorax group proteins, Genome organization, Transcriptional bursting, Phase separation; Epigenetics & human diseases/Aging, Transgenerational epigenetic inheritance, climate change adaptation, Epigenomics: Chip-Seq, ATAC-Seq, MeDip-Seq, 4C, HiC, FISH, Pyrosequencing etc.

Developmental Genetics: Basic concept in Developmental biology, Genetic and epigenetic basis of developmental pathways in mammals; Sex determination & Sex chromosome evolution, Stem cell & regeneration, nuclear transfer, Cellular reprogramming.

Srimonta Gayen

Pre-requistes : None

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.

Deepak Kumar Saini , Nikhil R. Gandasi

Pre-requistes : None

References : None

RD 213 (AUG) 2 : 0

Stem cells and Mammalian development

Early embryonic development: Gametogenesis, Germ cells, Fertilization, Early embryogenesis, Implantation, Gastrulation, Stem cell potency, Embryonic stem cells, Epiblast stem cells, Trophoblast stem cells, Stem cell differentiation, In vitro fertilization (IVF), Induced pluripotent stem cells and regeneration, genetic and epigenetic regulation of developmental pathways, X chromosome inactivation, genomic imprinting. Adult stem cells: Hematopoietic stem cells: Self-renewal, Differentiation, HSC enrichment, Transplantation, leukemia stem cells. Mammary gland development: Ductal morphogenesis, Alveologenesis, Involution and Regeneration, Hormones and Signaling pathways, Mammary stem cells, Breast cancer, Breast cancer stem cells.

Annapoorni Rangarajan , Srimonta Gayen

Pre-requistes : None

References : References:
1) Mammalian Development: Networks, Switches, and Morphogenetic Processes Edited by Patrick P.L. Tam, Children's Medical Research Institute; W. James Nelson, Stanford University; Janet Rossant, The Hospital for

Life Sciences

Preface

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.

Deepak Kumar Saini , 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 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

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-function

Samay Ravindra Pande

Pre-requistes : None

References :

Stanier, R.V., Adelberg E.A and Ingraham J.L., GENERAL MICROBIOLOGY, Macmillan Press, Fourth 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.

Garima Jindal

Pre-requisites : None

References :

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

CD 204 (AUG) 3 : 0

Chemistry of Materials

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

Natarajan S

Pre-requisites : None

References : None

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.

Sujit Das

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

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.

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.

Sandya S

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)

Materials Research Centre

Preface

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 309 (AUG) 3 : 0

Introduction to Supramolecular Chemistry

Course description: Supramolecular chemistry is "chemistry beyond the molecule". It is an interdisciplinary field that covers the physical, chemical and biological properties of complex chemical species held together mainly by non-covalent interactions. This course provides an introduction to the field, and discusses the intermolecular forces that dictate the formation of supermolecules and supramolecular assemblies and their properties. In addition, current trends are discussed using recent publications in this area. Course outline: This course is designed to be modular and includes the following topics: Molecular recognition, Host-Guest Chemistry; Receptors, Coordination and the "Lock and Key" Analogy; Chelate, Conformational and Macrocyclic Effects; Pre- organisation and Complementarity; Thermodynamic and Kinetic Selectivity; Selectivity and Solution Behaviour of Crown Ethers,Cryptands,Spherands; Complexation of Organic Cations; Biological anion receptors; Anti- crowns.

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 Polika
2. Organic light- emitting diodes (OLEDs) by Alastair Buckley
3. Color Vision and Colorimetry Theory and Applications by Daniel Malacara

MR 311 (AUG) 3 : 0

Additive Manufacturing: Concepts, process science

The course content involves concepts on Additive Manufacturing: Concept and importance, Fundamentals of engineering design, Basic elements, STL file format, knowledge on Computer softwares, Structure and properties of engineering materials, Overview of Important AM processes, High energy laser/electron beam, UV/laser-stereolithography, concepts of 3D inkjet printing, Process Science of selected AM process, Binderjet 3D printing, 3D extrusion printing, Laser-powder bed fusion, Directed energy deposition, Scientific case study, Binderjet 3D printing of Ti6Al4V, Binderjet 3D printing of ZrO2, Binderjet 3D printing of (Sr, Mg)-phosphate, 3D extrusion printing of Gelatin methacrylate-based hybrid biomaterials inks, DED of stainless steel, L-PBF of Ti6Al4V, Clinical applications of 3D printing, Regenerative engineering, Translational case study: Cranioplasty surgery, Emerging opportunities, AI/ML approaches in 3D printing, Regression analysis of 3D printing process prediction, Classification analysis of AM-part quality, AM under microgravity conditions, Current challenges and future perspectives
Topics include: additive processing of polymers, metals, and ceramics; computational design for AM; 3D metrology; material properties; cost/value analysis; and industrialization. Students will gain hands-on experience using state-of-the-art AM equipment to investigate process capabilities, and will learn advanced design software to support labs and assignments. Students will propose project topics such as: design, prototyping and business case analysis of a new AM-enabled product; a new hardware module to improve a machine/process; or an experimental study of process/material performance.

Bikramjit Basu

Pre-requistes :
Additive manufacturing, defined as layer-by-layer deposition of materials as per design of an object, has been playing significant
References : Reference books:
Ian Gibson, David Rosen, Brent Stucker, Mahyar Khorasani; Additive Manufacturing Technologies; Third Edition, Springer, 2021. (https://link.springer.com/content/pdf/10.1007/978-3-030-56127-7.pdf)

Organic Chemistry

Preface

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

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.

Awadhesh Narayan

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 , Sai Gautam Gopalakrishnan

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

Partha Sarathi Mukherjee , Abhishake Mondal

Pre-requistes : None

References :

(1) A collection of interesting general chemistry experiments, Elias AJ, Universities Press, 2008

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 220 (AUG) 3 : 1

Graph Theory

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

Sunil Chandran L

Pre-requistes : None

References : None

E0 224 (AUG) 3 : 1

Computational Complexity Theory

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

Chandan Saha

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.

Sathish Govindarajan , Anand Louis

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

Shalabh Bhatnagar

Pre-requistes : None

References : None

E0 234 (JAN) 3 : 1

Introduction to Randomized Algorithms

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.

Sanjit Chatterjee , 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.).

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.

Shirish Krishnaji Shevade

Pre-requistes : None

References :
References:
A.V. Aho, J.E. Hopcroft, and J.D.Ullman, Data Structures and Algorithms,

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.

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 304 (JAN) 3 : 1

Computational Cognitive Neuroscience

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

Pre-requistes : None

References : None

E0 309 (JAN) 3 : 1

Topics in complexity theory

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

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 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.

Pre-requistes : None

References : None

E0 374 (JAN) 3 : 1

Topics in Combinatorial Geometry

Pre-requistes : None

References : None

E0 399 (MAY) 1 : 2

Research in Computer Science

Contemporary topics of research in theoretical computer science, computer systems and software, intelligent systems.

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

Pre-requistes : None

References :

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.

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.

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

Gugan Chandrashekhar Thoppe

Pre-requistes : None

References : None

E0 205 (JAN) 3 : 1

Mathematical Logic and Theorem Proving

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

Pre-requistes : None

References :
First-order Logic and automated theorem proving, Melvin Fitting, Springer-Verlag, 1990.~Logic for Computer Science -- Foundations for

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,

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 (AUG) 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

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

CS 299 (JAN) 0 : 21

M Tech Project CSA

M Tech Project

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.

Pre-requistes :

Linear Algebra and Probability (3:1) or equivalent course

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 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.

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 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

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

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 317 (JAN) 3 : 0

Probabilistic Methods in Graph Theory and Combinat

Linearity of Expectation
Alterations, Second Moment Method, Lovasz Local Lemma,
Chernoff bound and its application,
Derandomization, Martingales, Markov Chains and Random walks,
Entropy and randomness.

Pre-requistes :

Basic exposure to Probability theory, Graph Theory/Combinatorics.

References : (1) N. Alon, J. Spenser, The Probabilistic Methods, WILEY-INTERSCIENCE SERIES IN DISCRETE MATHEMATICS AND OPTIMIZ

(2) Probability and Computing: Randomized Algorithms and Probabilistic Analysis; Mitzen Macher and Eli Upfal, Cambridge University Press.

E0 318 (AUG) 3 : 1

Topics in Geometric Algorithms

Geometric problems are ubiquitous in Computer Science. Indeed, one often encounters geometric problems—and associated algorithms—in data science applications; examples include geometric proximity problems and hashing methods that exploit the geometry of input points. In addition to critical applications, geometric algorithms connect with mathematical fields such as probability theory and topology. This course will cover algorithmic approaches for addressing topical problems in computational geometry. In particular, we will focus on Geometric Packing, Robot Motion Planning, Art Gallery and Visibility Problems, LSH and Nearest Neighbor, Coresets, Geometric Intersection Graphs, and Fair Partitioning. The course will address recent algorithmic developments in these topics. Further, by way of course projects, we will identify and explore some key open problems in the above-mentioned topics.

Siddharth Barman , Arindam Khan

Pre-requistes :

Students should have completed either Computational Geometry (E0

References : Since the course topics span several fields, we will be teaching material from multiple books/sources. Some of them are listed below.

a. Sariel Har-Peled, Geometric Approximation Algorithms. American Mathematical Soc., 2011.
b. Mark DB, Otfried C, Marc VK, Mark O. Computational geometry algorithms and applications. Springer; 2008.

Electrical Communication Engineering

Preface

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 (AUG) 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 245 (AUG) 3 : 0

Online Prediction and Learning

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

Aditya Gopalan , Rahul Singh

Pre-requistes : None

References :
Prediction, Learning and Games. Nicolo Cesa-Bianchi and Gabor Lugosi,Cambridge University Press, 2006~Online Learning and Online

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 205 (AUG) 3 : 0

Error-Control Coding

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

Vijay Kumar P

Pre-requistes : None

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

E2 211 (AUG) 3 : 0

Digital Communication

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

Sundar Rajan B

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.

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.

Chandramani Kishore Singh , 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 communi

Chockalingam A

Pre-requistes : None

References :
Tony J. Rouphael. Wireless Receiver Architectures and Design:,Antenna, RF,Synthesizers, Mixed Signal and Digital Signal Processing. Academic

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

E8 202 (AUG) 2 : 1

Computational Electromagnetics

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

Dipanjan Gope

Pre-requistes : None

References :
A. Taflove and SC Hagness Computational Electrodynamics: The Finite Difference Time Domain Method, 3rd Ed., Artech House.~Andrew F.

E8 311 (AUG) 2 : 1

Advanced Topics in Electromagnetics

Vinoy K J

Pre-requistes : None

References : None

E9 208 (AUG) 3 : 1

Digital Video: Perception and Algorithms

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

Rajiv Soundararajan

Pre-requistes : None

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

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-requistes :

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.

E9 333 (AUG) 3 : 1

Advanced Deep Representation Learning

Reference Material:

1. Understanding Machine Learning: From Theory to Algorithms, Shai Shalev-Shwartz and Shai Ben-David, Cambridge University Press

2. Murphy, Kevin P. Probabilistic Machine Learning: Advanced Topics, MIT Press, 2023

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

4. Deisenroth, Marc Peter, A. Aldo Faisal, and Cheng Soon Ong. Mathematics For Machine Learning. Cambridge University Press, 2020.

5. Machine Learning from Weak Supervision: An Empirical Risk Minimization Approach, By Masashi Sugiyama, Han Bao, Takashi Ishida, Nan Lu, Tomoya Sakai and Gang Niu, MIT Press

6. Deep Generative Modeling, Jakub M. Tomczak, Springer 2022

7. Semi-Supervised Learning, Olivier Chapelle, Bernhard Schölkopf and Alexander Zien, MIT Press

8. Seminal and Survey papers from Machine Learning Conferences such as ICML, Neurips, ICLR, CVPR, AISTATS etc.

Prathosh A.P

Pre-requistes :

References :
Recap on Fundamentals of Deep Learning: Empirical Risk Minimization, Divergence minimizations and Likelihood maximization Techniques, Deep

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.

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 inequality

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-

Electrical Engineering

Preface

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

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.

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”

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.

Satish L , Rajanikanth B S

Pre-requistes : None

References : References: Bernard Hochart, Power Transformer Handbook,Butterworth, 1987.,The J & P Transformer Book,12th Edn, MJ Heathcote, Newnes, 1998.

E5 213 (AUG) 3 : 0

EHV/UHV Power Transmission Engineering

Joy Thomas M

Pre-requistes : None

References : None

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 :
References: Mohan N, Power Electronics; Principles, Analysis and Design , John Wiley, 1989.,Robert Ericson, Fundamentals of Power Electronics,

E6 224 (AUG) 3 : 0

Topics in Power Electronics and Distributed Generation

Introduction to distribution systems, fault calculations, fault contribution and protection coordination with Distributed Generation (DG), intentional and unintentional islanding, impact on distribution system voltage profile,relaying requirements for DG systems. Power converters for grid interconnection and micro-source-side power converter topologies, inverter modeling, component selection, design for efficiency and reliability,grounding and filtering requirements. Power converter design trade-off considering efficiency and reliability. Control requirements for DG, phase locking, current control, DC bus control, power quality, unbalance, harmonics,surges, voltage and frequency windows.

Vinod John

Pre-requistes : None

References :
V. Ramanarayanan, Switched Mode Power Conversion, 2010.~Arthur R, Bergen,Vittal, Power Systems Analysis (2nd Ed) Prentice Hall, 1999. ~Ned

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.

E1 246 (AUG) 3 : 0

Topics in Networked and Distributed Control

Core topics:
Relevant background topics in control;

Estimation and control under communication constraints such as sampling, quantization, packet losses; data rate limited control;

Consensus, synchronization, coverage control, multi-agent systems.

Selected topics from:
Event-triggered control, connectivity maintenance, distributed estimation, distributed optimization, distributed hypothesis testing, privacy and security in networked and distributed control systems, social networks, opinion dynamics, epidemic spread, applications in robotics and transportation.

Vaibhav Katewa

Pre-requistes : None

References : 1. Bemporad, Alberto, Maurice Heemels, and Mikael Johansson. "Networked control systems". Vol. 406. London: Springer, 2010.

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

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

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

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.

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 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;

Naga Krishna V.

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 Verghese

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 J Pandya

Pre-requistes : None

References : None

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

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

Umanand L

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 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 :

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.

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

BE 203 (AUG) 0 : 1

Bioengineering Practicum 1

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,

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,

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

Sanhita Sinharay

Pre-requistes : None

References : None

BE 219 (AUG) 2 : 0

Essentials of Research and Innovation

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 /biochemical 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
Th

Siddharth Jhunjhunwala , Sanhita Sinharay

Pre-requistes :

References :
References
1. Organic chemistry- Clayden, Greeves and Warren

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 213 (AUG) 3 : 0

Introduction to Photonics

This is a foundation level optics course which intends to prepare students to pursue advanced topics in more specialized areas of optics such as biophotonics, nanophotonics, non-linear optics etc. Classical and quantum descriptions of light, diffraction, interference, polarization. Fourier optics, holography, imaging, anisotropic materials, optical modulation, waveguidesand fiber optics, coherence and lasers, plasmonics.

Ambarish Ghosh , Shankar Kumar Selvaraja

Pre-requistes : None

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 , Dhavala Suri

Pre-requistes : None

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

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 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 (MAY) 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

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 department. Owing to the extensive use of lasers in various fields, we believe a good understanding of these principles is essential for students in all science and engineering disciplines.

Supradeepa V R , Balaswamy Velpula

Pre-requistes : None

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

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 206 (AUG) 3 : 0

Semiconductor Device Physics: Basic Devices

Energy bands in solids; Reciprocal space; Brillouin Zone (BZ); 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; PN junction under bias; Transient behavior of p-n junction; Solar cell and photodetector; Metal-semiconductor (Schottky and Ohmic junctions; Current transport mechanisms; Introduction to compound semiconductors; BJT; MOS capacitor; MOSFET; Short channel effects

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 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 optical funct

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 findings 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

NE 201B (AUG) 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, oscilloscope/function generator, basics of VNA and small-signal parameters

Akshay K Naik

Pre-requistes :

References : Notes

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

Pre-requistes : None

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).

Shankar Kumar Selvaraja , Supradeepa V R , 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

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. Wafer dicing, 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 , Chandan Kumar

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

NE 200A (AUG) 3 : 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. In the current updated version for the updating of the MTech program, we have included the much needed context associated with giving technical talks, seminars and other forms of public dissemination.

Supradeepa V R

Pre-requistes : None

References : The Elements of Style William Strunk Jr. and E.B. White 4th Edition Longman,Academic Writing Stephen Bailey 2nd Edition Routledge,The Elements of Technical Writing Gary Blake and Robert W Bly - Longman

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.

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

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.

Sekar K

Pre-requistes : None

References :
C.Branden and J.Tooze (eds) Introduction to Protein Structure, Garland,1991~Mount, D.W., Bioinformatics: Sequence and Genome Analysis,

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

Pre-requistes : None

References : None

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

Phaneendra Kumar Yalavarthy

Pre-requistes : None

References : None

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 Computational 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,

References :

1. Athanasios Papoulis and S. Unnikrishna Pillai, Probability, Random Variables and Stochastic Processes, McGraw Hill Education, 2017.

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-requisites :

Basic knowledge of Systems and Signals, Proficiency in

References :

Main Text Books:
Kevin Zhou, Medical Image Recognition, Segmentation

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-requisites :
The class is intended for graduate students and senior undergraduates. Students should have finished at least a basic machine learning

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 :
A first course in data analysis or machine learning (e.g., DS 216, E1 213, E0 270, DS 265 etc.) is a mandatory requirement. A course in
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 –

Preface

Energy Research

Preface

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

Pre-requistes : None

References : None

ER 207 (AUG) 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

Water Research

Preface

Preface

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.

Ramesh O N

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 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.

Suresh Sundaram

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 211 (AUG) 3 : 0

Mathematical Methods of Aerospace Engineers

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

Kartik Venkatraman , Rajesh Chaunsali

Pre-requistes : None

References : Erwin Kreysig, Advanced Engineering Mathematics Wiley 2015.

AE 228 (AUG) 2 : 1

Computation of Viscous Flows

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

Kartik Venkatraman , Balakrishnan N

Pre-requistes : None

References : None

AE 255 (AUG) 3 : 0

Aeroelasticity

Effect of wing flexibility on lift distribution; Torsional wing divergence; Vibration of single, two, and multi-degree of freedom models of wing with control surfaces; Unsteady aerodynamics of oscillating airfoil; Bending-torsion flutter of wing; Gust response of an aeroelastic airplane;Aeroservoelasticity of wing with control surfaces.

Kartik Venkatraman

Pre-requistes : None

References : Wright, J.R., and Cooper, J.E., Introduction to Aircraft Aeroelasticity and Loads, John Wiley, 2008.~Hodges, D.H., and Alvin Pierce, G., Introduction to Structural Dynamics and Aeroelasticity, Cambridge University Press, 2002.~Fung, Y.C., An Introduction to the Theory of Aeroelasticity, Dover edition, 2002.~Bisplinghoff, R.L., Ashley, H., and Halfman, R.L., Aeroelasticity, Dover edition, 1996.

AE 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

AE 291 (AUG) 3 : 0

Special topics in aerospace engineering 1

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

Aravind Balan

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

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.,

Atmospheric and Oceanic Sciences

Preface

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 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 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

Earth Sciences

Preface

ES 202 (AUG) 3 : 0

Biogeochemistry

Prosenjit Ghosh

Pre-requistes : None

References : None

ES 204 (AUG) 3 : 0

Origin and Evolution of the Earth

Big Bang; origin of elements; early solar system objects; bulk Earth composition; comparison of Earth and other Solar System objects; core-mantle differentiation; composition of the terrestrial mantle; mantle melting and geochemical variability of magmas; major, trace element and radiogenic isotope geochemistry; redox evolution of the mantle; evolution of the atmosphere and biosphere.

Ramananda Chakrabarti

Pre-requistes : None

References :
Charles H. Langmuir and Wally Broecker, How to build a habitable planet, Revised and expanded edition, Princeton University Press, 2012;~A. P. Dickin,

ES 215 (AUG) 3 : 0

Introduction to Chemical Oceanography

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

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,

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.

Sustainable Technologies

Preface

ST 203 (AUG) 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

Pre-requistes : None

References : None

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.,

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.

ST 216 (AUG) 3 : 0

Physics in Experiments with Classical Statistics

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

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

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 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 harves?ng.

Surface, ground & rainwater quality. Contamina?on scenarios & need for treatment. Drinking water treatment & requirements. Other remedia?on techniques. Industrial water treatment & requirements.

Seawater desalina?on.

Wastewater quan?ty & quality, parameters. Water pollu?on, hazards & need for wastewater treatment. Conven?onalwastewater treatment. Resource recovery op?ons.Recycling of treated wastewater. Op?onsfor 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.

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. https://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

Pre-requistes : None

References : M. Kanoglu, Y. A. Cengel, J. M. Cimbala Fundamentals and Applica?ons of Renewable Energy 2019 McGraw-Hill Educa?on ISBN: 978-1260455304

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.

Narendra M Dixit

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

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 Punnathanam

Pre-requistes : None

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

CH 206 (AUG) 1 : 0

Seminar Course

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

Rahul Roy

Pre-requistes : None

References : None

CH 252 (AUG) 3 : 0

Hydroprocessing

Importance of Hydroprocessing; Catalysis for Hydroprocessing; Hydrogen Management in Refineries; Hydrodesulfurisation; Hydrocracking; Process Integration; Modeling for Hydroprocessing; Design of Trickle Bed Reactor for Hydroprocessing; Process Safety

Venugopal S

Pre-requistes :
Batchelor's level course on Chemical Reaction Engineering

References : 1. Verma RP, Bhatnagar AK (ed) "Hydroprocessing in petroleum refining industry – a compendium". Lovraj Kumar memorial trust, Indian oil Institute of Petroleum Management, Gurgaon, India, (2000)
2. Nigam KDP, Schumpe A (ed) "Three phase sparged reactors", Gordon and Breach Publishers (1996)

Civil Engineering

Preface

CE 269 (AUG) 3 : 0

Traffic Engineering

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

Vijay Gopal Kovvali

Pre-requistes : None

References : Roess, R.P., Prassas E.S. & McShane, W.R. (2010), Traffic Engineering, Prentice Hall, USA.~May, A. D. (1990), Traffic Flow Fundamentals, Prentice Hall, USA.~Highway Capacity Manual (2010), Transportation Research Board, USA.~Kadiyali, L. R. (2000), Traffic Engineering and Transport Planning, Khanna Publishers, India.~Salter, R J. & Hounsell, N. B. (1996), Highway Traffic Analysis and Design,

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.

Climate Change

Preface

Materials Engineering

Preface

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 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 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 260 (AUG) 3 : 0

Polymer Science and Engineering

Fundamentals of polymer science. Polymer nomenclature and classification. Current theories for describing molecular weight, molecular weight distributions. Synthesis of monomers and polymers. Mechanisms of polymerization reactions. Introduction to polymer processing (thermoplastic and thermoset). Structure, property relationships of polymers: crystalline and amorphous states, the degree of crystallinity, cross-linking, and branching.Stereochemistry of polymers. Instrumental methods for the elucidation of polymer structure and properties; basic principles and unique problems encountered when techniques such as thermal (DSC, TGA, DMA, TMA, TOA),electrical, and spectroscopic (IR, Raman, NMR, ESCA, SIMS) analysis GPC, GC-MS, applied to polymeric materials. Polymer Processing - Injection Molding, Extrusion, Compression Molding, Blow Molding, Casting and Spin Coat, Calendaring.

Suryasarathi Bose

Pre-requistes : None

References : None

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 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 Materials

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)

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

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

Mechanical Engineering

Preface

ME 246 (AUG) 2 : 1

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 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 225 (AUG) 1 : 0

Introduction to Soft Matter

Introductory course on soft matter/complex fluids. A review of preliminaries of continuum mechanics, which are required for dealing with soft matter. General concepts of viscous and elastic deformations and relevant models.Experimental approaches to soft materials such as creep response and stress relaxation.

Aloke Kumar

Pre-requistes : None

References : Bird, R.B., Armstrong, R.C., Hassager, O., Dynamics of Polymeric Fluids, John Wiley and Sons~Joseph, D.D, Fluid Dynamics of Viscoelastic Liquids, Spinger-Verlag, 1990~Gurtin,M.E., Fried, E., Anand, L.The Mechanics and Thermodynamicsof Continua, Cambridge University Press 2011~R.C.~Hassager

ME 242 (AUG) 3 : 0

Solid Mechanics

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

Ramsharan Rangarajan , Debashish Das

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 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 260 (AUG) 3 : 0

Topology Optimization

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

Ananthasuresh G K

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

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

Pre-requistes : None

References : None

ME 274 (AUG) 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.

Pramod Kumar

Pre-requistes : None

References : None

ME 283 (AUG) 3 : 0

Two Phase Flows and Boiling Heat Transfer

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

Susmita Dash

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.

Narasimham G S V L

Pre-requistes : None

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

ME 260 (AUG) 3 : 0

Structural Optimiztion:Size, Shape, and Topology

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

Ananthasuresh G K

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

ME 280 (AUG) 3 : 0

Fundamentals of nanoscale conduction heat transport

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

Navaneetha Krishnan Ravichandran

Pre-requistes : None

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

ME 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 scipy.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

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 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 :
Basic knowledge of solid mechanics.

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.

ME 306 (AUG) 3 : 0

Analytical and Statistical Thermodynamics

This course will cover mathematical aspects of macroscale and microscopic thermodynamics. The prerequisites for this course are courses in engineering mathematics and basic thermodynamics.

The course will be covered in four parts:
1. Classical theory of thermodynamics: Geometry of fundamental relations, Caratheodory's theorem, thermodynamic potentials;
2. Thermodynamic stability: Phase equilibria and separation, thermodynamics of surfaces and multi-component systems
3. Statistical equilibrium thermodynamics: Microcanonical and canonical ensembles, Ising model solution, correlation functions and phase change
4. Non-equilibrium thermodynamics: Langevin equation, fluctuation-dissipation theorem, Fokker-Planck equation, Diffusion equation and dynamic mobility

Gaurav Tomar , Koushik Viswanathan

Pre-requistes :
The prerequisites for this course are courses in engineering mathematics and basic thermodynamics.

References :
1. H Callen, Thermodynamics and an introduction to thermostatistics
2. S Safran, Statistical Thermodynamics of Surfaces, Interfaces and Membranes
3. F Reif, Statistical Physics (Berekely Physics Series Vol. 5)

Preface

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.

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 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 , Nadig D S

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 386 (AUG) 3 : 0

Experimental High Energy Physics

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

Sudhir Kumar Vempati , Jyothsna Rani Komaragiri

Pre-requistes : None

References : None

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

HE 380 (AUG) 3 : 0

3D Quantum Gravity and 2D Conformal Field Theory

3D gravity, Chern-Simons formulation, BTZ black hole as a quotient, Brown-Henneaux, Virasoro algebra, central charge, 2D CFT (basics, state-operator map, OPE, boostrap, Virasoro blocks, modular invariance), BTZ entropy from Cardy, large-c and AdS3/CFT2, HLLH 4-point functions, semi-classical Virasoro blocks and information loss.

Chethan Krishnan

Pre-requistes : General Relativity HE398 and Quantum Field Theory II HE396 are useful as prerequisites. Get permission of instructor if you have not taken

References : 1. Di Francesco et al. for 2D Conformal Field Theory.
2. Carlip for 3D quantum gravity, but more up to date references will be suggested in class

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 214 (AUG) 3 : 0

Semiconductor Devices and Circuits

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

Sanjiv Sambandan

Pre-requistes : None

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

IN 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 , Sai Siva Gorthi , Manish Arora

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

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

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 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

IN 280 (AUG) 2 : 1

Optical Instrumentation

Building-Blocks of Optical Instrumentation: Properties of Light and Physical Principles (Refraction, Diffraction, Scattering and Interference), Optical Components (such as Elements, Sources and Detectors) and Modules (such as Optical Fibers and Imaging Systems), Optical Sensors and Transducers.

Design & Characterization of Optical Systems: Signals, Systems, Analysis, Measurement, Characterization and Calibration. Point-Spread Function, Optical Transfer Function. Specific Tutorials and Case-Studies on Optical Microscopy and Spectroscopy Techniques.

Simulations with MATLAB / Python: Signal Processing and Image Processing Tools, Hardware Interfacing, Data Acquisition and Analysis, Signal-to-Noise Ratio, Digital Image Correlation, Fourier Transform based Analysis.

Experiments in Optics Laboratory: Hands-on training on Optical Alignments, building Pulse-oximeter / Hemoglobinometer, Michelson Interferometer, and Digital Brightfield Microscope. This lab component of the course will combine the learnings from different modules of the course: Basic Concepts, Applied Theory and Computational Tools.

Sai Siva Gorthi

Pre-requistes :

No Prerequisites. This is an introductory level course suitable

References : “Handbook of Optical Sensors” José Luís Santos , Faramarz Farahi; CRC Press; ISBN: 9781439866856

“Optical Sensors: Basics and Applications” by Jörg Haus; Wiley-VCH, ISBN: 978-3527408603

Mathematics

Preface

MA 224 (MAY) 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).

Pre-requistes : None

References : None

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.

Siddhartha Gadgil

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 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.

Sanchayan Sen

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

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.

Vamsi Pritham Pingali

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 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.

Manjunath Krishnapur

Pre-requistes : None

References :
Rick Durrett, Probability: theory and examples., Cambridge University Press,2010~David Williams, Probability with Martingales, Cambridge

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.

Muna Naik

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 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.

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 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.

Nirmal Raj

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

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.

Sumantra Sarkar

Pre-requistes : None

References :

PH 203 (AUG) 3 : 0

Quantum Mechanics-I

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

Diptiman Sen

Pre-requistes : None

References : None

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

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.

Chandni U

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 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

Tanmoy Das

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

Pre-requistes : None

References : None

PH 353 (AUG) 3 : 0

Principles of Magnetism

Srimanta Middey

Pre-requistes : None

References : None

PH 380 (AUG) 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 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 Bowmik

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

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.

Tarun Deep Saini

Pre-requistes :
None

References : G. Rybicki & A. Lightman: Radiative Processes in Astrophysics

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.

Navin Kashyap , Shayan Garani Srinivasa

Pre-requistes : None

References :
Nielsen M.A. and Chuang I.L., Quantum Computation and Quantum Information, Cambridge University Press, 2000.Peres A., Quantum Theory:

QT 201 (AUG) 1 : 0

Survey of Quantum Technologies

Introductory lectures by IISc faculty on the variety of developments in quantum technology. Augmented by seminars from leading researchers around the world.

Baladitya Suri

Pre-requistes :

None

References :
Online talks.

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

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, Characterisation 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 203 (AUG) 3 : 0

Physics and Engineering Foundations for Quantum Te

Introductory lectures by IISc faculty on the variety of developments in quantum technology. Augmented by seminars from leading researchers around the world.
Basics of Quantum Mechanics -- Postulates of quantum mechanics, harmonic oscillator, time dependent perturbation theory, Rabi problem, Unitary transformations and Qubit Gates, basics of quantum optics,Coherent states, Wigner distribution,
Basics of Electrodynamics -- Maxwells equations, light-matter interaction, Dipole approximation, Radiation, circuit lagrangians, transmission line equations.
Basics of Solid state physics -- Drude model, Periodic potential and Bloch Theory, Hartree-Fock approximation, Solid state qubit devices.

Baladitya Suri

Pre-requistes :

None
References :
Online talks.
J J Sakurai -- Modern Quantum Mechanics (any edition)