भारतीय विज्ञान संस्थान

Scheme of Instructions

Aug-Dec 2025 Term

Preface

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

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

The listing of each course consists of the course number, the title, the number of credits and the semester. The course number indicates both the department and the level of the course. For instance, MA 205 indicates that the course is offered by the Mathematics department and is at the 200 level. Such 200 level courses are either basic or second level graduate courses. The 300 level courses are advanced courses primarily meant for research scholars, but can also be taken by course students who have the appropriate background; these courses can be taken only with the consent of the instructors. Most courses are offered only once a year, either in the August or in the January semester. 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 post-graduate degree, the RTP requirement is a minimum of 12 credits. For PhD students in Engineering who join with under-graduate degree, the RTP consists of a minimum of 24 credits. Similar RTP requirements apply for students who upgrade or continue their registration from the Masters programmes of the Institute. For the research-based Master’s degree, the RTP consists of minimum 12 credits. The Integrated PhD programme has 64 credits. Research students have the option of crediting courses beyond the RTP requirement as detailed in the Student Information Handbook.

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

Chair
Senate Curriculum Committee

Division of Biological Sciences

Preface

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

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

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

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

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

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

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

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

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

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

Prof. Usha Vijayaraghavan

Dean,

Division of Biological Sciences

DB 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.

Shantanu P Shukla

Pre-requisites : None

References : None

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.

Debabrata Laha , Payel Roy

Pre-requistes : None

References : None

Ecological Sciences

Preface

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

EC 301 (AUG) 2 : 1

Animal Behaviour : Mechanisms and Evolution

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

Kavita Isvaran

Pre-requistes : None

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

EC 302 (AUG) 2 : 1

Plant-Animal Interactions (Ecology, Behaviour and Evolution)

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

Saskya Daly Van Nouhuys

Pre-requistes : None

References : None

EC 303 (AUG) 2 : 1

Stochastic and Spatial Dynamics in Biology

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

Vishwesha Guttal

Pre-requistes : None

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

EC 305 (AUG) 2 : 1

Quantitative Ecology : Research Design and Inference

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

Kartik Shanker , Umesh Srinivasan

Pre-requistes : None

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

EC 101 (AUG) 1 : 0

Process of Scientific Thinking

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

Maria Thaker

Pre-requistes : None

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

EC 202 (AUG) 2 : 1

Ecology: Pattern and Process

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

Umesh Srinivasan

Pre-requistes : None

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

Neuroscience

Preface

NS 201 (AUG) 2 : 0

Systems Neuroscience

Neuronal biophysics, sensation & perception, motor systems

Aditya Murthy , S P Arun , Supratim Ray

Pre-requistes : None

References :

NS 202 (AUG) 2 : 0

Molecular and Cellular Basis of Behaviour

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

Balaji J , Deepak Kumaran Nair

Pre-requistes : None

References : None

NS 203 (AUG) 2 : 0

Cognitive Neuroscience

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

Sridharan Devarajan , 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 212 (JAN) 2 : 1

Neural Signal Processing

Neuronal biophysics, sensation & perception, motor systems Biophysics and computational techniques for the analysis of action potentials, Local Field Potential (LFP) and Electroencephalogram (EEG). Techniques include stochastic processes, time-frequency analysis, sparse signal processing, coherence, ICA/PCA, forward and inverse modeling and Granger causality.

Pre-requistes : None

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

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 MICROBIOLOGY, Macmillan Press, Fourth edition Westriech, G.A. and Lechmann M.D., MICROBIOLOGY,Macmillan Press, Fifth Edition Atlas R.M.,MICROBIOLOGY: FUNDAMENTALS AND APPLICATIONS, Macmillan Press Second Edition Goldsby, R. A.,Kindt T. J.,Osborne B. A., Kuby J.,IMMUNOLOGY, W. H. Freeman &

MC 206 (AUG) 2 : 0

RNA Biology

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

Saumitra Das , Purusharth Rajyaguru

Pre-requistes :

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

MC 208 (AUG) 2 : 0

Principles of Genetic Engineering

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

Shashank Tripathi , Naresh Loudya

Pre-requistes : None

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

MC 212 (AUG) 2 : 0

Advances in Cell Biology

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

Subba Rao Gangi Setty , Sachin Kotak

Pre-requistes : None

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

MC 205 (AUG) 2 : 0

Pathogen - Host interactions and immune evasion mechanisms

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

Balaji Kithiganahalli , Dipshikha Chakravortty

Pre-requistes : None

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

MC 218 (AUG) 2 : 0

Advances in Molecular Biology

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

Shovamayee Maharana

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

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

Molecular Biophysics Unit

Preface

MB 201 (AUG) 2 : 0

Introduction to Biophysical Chemistry

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

Ashok Sekhar

Pre-requistes : None

References : None

MB 204 (AUG) 3 : 0

Molecular Spectroscopy and its Biological Applications

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

Siddhartha P Sarma

Pre-requistes : None

References : None

MB 206 (AUG) 3 : 0

Conformational and Structural aspects of biopolymers

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

Mahavir Singh , Anand Srivastava , Vidya Mangala Prasad

Pre-requistes :

Basic knowledge in matrix, probability theory, basic physics

References : None

MB 208 (JAN) 3 : 1

Theoretical and Computational Neuroscience

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

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

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

MB 202 (AUG) 3 : 0

Introduction to Macromolecular X-ray Crystallography

Crystal morphology and symmetry. Symmetry elements and symmetry operations, point groups, lattice space groups. Production and properties of X-rays, diffraction of X-rays by crystals, Laue equations, Bragg'sLaw, Fourier transformation and structure factor, reciprocal lattice, experimental phasing methods . Basic ideas of structure determination, Patterson and Fourier methods, refinement procedures.

Aravind Penmatsa

Pre-requistes : None

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

Developmental Biology and Genetics

Preface

RD 204 (AUG) 2 : 0

Principles of Signal Transduction in Biological Systems

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

Nikhil R. Gandasi

Pre-requistes : None

References : None

RD 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: Introduction to adult stem cells, stem cell techniques for isolation, symmetric vs asymmetric stem cell division. Hematopoietic stem cells: Self-renewal, differentiation, flowcytometry based HSC isolation, transplantation and clonogenicity assays, Wnt and Notch pathway in stem cell maintenance. Mammary gland development, hormones and signaling pathways, mammary stem cells. Stem cells and Cancer.

Annapoorni Rangarajan

Pre-requistes : None

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 Sick Children. ISBN 978-1-936113-24-8

Life Sciences

Preface

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

LS 102 (AUG) 1 : 0

Opportunities and Extensions in Life Sciences - Pa

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

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

Maria Thaker

Pre-requistes : None

References : will be provided

LS 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

Pre-requistes : None

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

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.

Vignesh Palani

Pre-requisites : None

References :

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

CD 211 (AUG) 3 : 0

Physical Chemistry – I Quantum Chemistry and Group Theory

Postulates of Quantum Mechanics and introduction to operators; Wave Packets,Exactly solvable problems Perturbational, Variational,and WKB Methods;Angular Momentum and Rotations, Hydrogen Atom, Zeeman and Stark effects, Manyelectron Atoms, Slater determinants, Hartree-Fock Variational Method for atoms; Symmetry and Group theory,Point Groups, Reducible and Irreducible Representations (IR), Great Orthogonality theorem, Projection operators,Applications to molecular orbitals and normal modes of vibration and selection rules in spectroscopy.

Abhishek Sirohiwal

Pre-requisites : None

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

CD 215 (AUG) 0 : 4

Organic & Inorganic Chemistry Laboratory

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

Partha Sarathi Mukherjee,Abhishake Mondal,Sharvan Kumar

Pre-requisites : None

References : None

CD 402 (AUG) 3 : 0

Molecular Spectroscopy, Dynamics and Photochemistry

Energy levels of molecules and their symmetry. Polyatomic rotations and normal mode vibrations. Electronic energy states and conical intersections; time-dependent perturbation theory and selection rules; microwave, infrared and Raman, electronic spectroscopy; energy transfer by collisions, both inter and intra-molecular. Unimolecular and bimolecular reactions and relations between molecularity and order of reactions, rate laws; temperature and energy dependence of rate constants, collision theory and transition state theory, RRKM and other statistical theories; photochemistry, quantum yield,photochemical reactions, chemiluminescence, bioluminescence, kinetics and photophysics.

Soumen Ghosh

Pre-requisites : None

References : None

CD 212 (AUG) 3 : 0

Inorganic Chemistry – Main group and coordination chemistry

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

Geetharani K,Abhishake Mondal

Pre-requisites : None

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

Inorganic and Physical Chemistry

Preface

IP 203 (AUG) 3 : 0

Group Theory and Molecular Spectroscopy

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

Anoop Thomas

Pre-requistes : None

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

IP 311 (AUG) 3 : 0

Bio and Medicinal Inorganic Chemistry

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

Debasis Das

Pre-requistes : None

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

IP 312 (AUG) 3 : 0

Advanced Organometallic Chemistry

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

Balaji R Jagirdar

Pre-requistes : None

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

Materials Research Centre

Preface

MR 310 (AUG) 3 : 0

Light emitting materials and devices

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

Rajamalli P

Pre-requistes : None

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

Organic Chemistry

Preface

Solid State and Structural Chemistry

Preface

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

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

Chemical Science

Preface

CY 215 (AUG) 0 : 3

Advanced Laboratory - 1

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

Abhishake Mondal

Pre-requistes : None

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

Division of EECS

Preface

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

E0 Computer Science and Engineering

E1 Intelligent Systems and Automation

E2 Communication Systems

E3 Electronic Devices, Circuits and Technology

E4 Power and Energy Systems

E5 High Voltage and Insulation Engineering

E6 Power Electronics and Drives

E7 Photonic Devices, Circuits and Systems

E8 Electromagnetic, Microwaves and Antennas

E9 Signal Processing, Acoustics and Bioengineering

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

M Tech in Electrical Engineering (EE)

M Tech in Communication and Networks (ECE)

M Tech in Computer Science and Engineering (CSA)

M Tech in Electronics Systems Engineering (ESE)

M Tech in Artificial Intelligence (CSA,ECE,EE,ESE)

M Tech in Signal Processing (EE and ECE)

M Tech in Microelectronics and VLSI Design (ECE and ESE)

The dissertation projects in the above M Tech programs are numbered EE 299, CN 299, CS 299, ES 299, Ai 299, SP 299, and MV 299, respectively. We wish all the students a lively and intellectually rewarding experience in the Division of EECS at the Indian Institute of Science.

Prof. Rajesh Sundaresan

Dean

Division of EECS

Computer Science and Automation

Preface

E0 238 (AUG) 3 : 1

Intelligent Agents

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

Pre-requistes : None

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

E0 224 (AUG) 3 : 1

Computational Complexity Theory

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

Chandan Saha

Pre-requistes : None

References : None

E0 225 (AUG) 3 : 1

Design and Analysis of Algorithms

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

Siddharth Barman , Arindam Khan , Rahul Saladi

Pre-requistes : None

References : None

E0 227 (AUG) 3 : 1

Program Analysis and Verification

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

Deepak D'Souza , Raghavan K V

Pre-requistes : None

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

E0 230 (AUG) 3 : 1

Computational Methods of Optimization

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

Chiranjib Bhattacharyya

Pre-requistes : None

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

E0 232 (AUG) 3 : 1

Probability and statistics

Gugan Chandrashekhar Mallika Thoppe

Pre-requistes : None

References : None

E0 235 (AUG) 3 : 1

Cryptography

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

Arpita Patra

Pre-requistes :

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

E0 240 (AUG) 3 : 1

Modeling and Simulation

Sumit Kumar Mandal

Pre-requistes : None

References : None

E0 243 (AUG) 3 : 1

Computer architecture

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

Govindarajan R , Arkaprava Basu

Pre-requistes : None

References : None

E0 249 (JAN) 3 : 1

Approximation Algorithms

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

Pre-requistes : None

References : None

E0 251 (AUG) 3 : 1

Data Structures and Algorithms

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

Sathish Govindarajan

Pre-requistes : None

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

E0 253 (JAN) 3 : 1

Operating Systems

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

Pre-requistes : None

References : None

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 334 (AUG) 3 : 1

Deep Learning for Natural Language Processing

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

Shirish Krishnaji Shevade

Pre-requistes : None

References :

E0 337 (AUG) 3 : 1

Topics in Advanced Cryptography

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

Bhavana Kanukurthi , Chaya Ganesh

Pre-requistes : None

References : None

E0 358 (AUG) 3 : 1

Advanced Techniques in Compilation and Programming for Parallel Architectures

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

Uday Kumar Reddy B

Pre-requistes : None

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

E1 396 (AUG) 3 : 1

Topics in Stochastic Approximation Algorithms

Shalabh Bhatnagar

Pre-requistes : None

References : None

E0 206 (AUG) 3 : 1

Theorist's Toolkit

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

Anand Louis

Pre-requistes : None

References : References: Since this is a “toolkit” course, we will be teaching material from multiple books/sources. Some of them are the following. ~a.Michael Mitzenmacher and Eli Upfal. Probability and computing: Randomization and probabilistic techniques in algorithms and data analysis. Cambridge university press, 2017. ~b.Ryan O'Donnell. Analysis of boolean functions. Cambridge University Press,2014. ~c.

E0 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 cours

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

E0 280 (JAN) 3 : 1

Deep Generative Models

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

Pre-requistes :

This course will build on E0270, E1213.

References : Relevant Literature

E0 214 (AUG) 3 : 0

Applied Linear Algebra and Optimization

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

Shirish Krishnaji Shevade

Pre-requistes : None

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

E0 319 (AUG) 3 : 0

Learning-Theoretic Foundations of Modern Machine L

- Decision Theory: Loss, risk, optimal predictors, Decomposition of excess risk
- Concentration inequalities: Hoeffding Inequality, Bernestein, Benett
- Ridge regression: Dimension independent bounds, operator based bound
- Estimation error: Finite number of hypotheses and covering numbers, Rademacher Complexity, VC dimension
- Consistent Estimators: Nadaraya-Watson estimators, K-nearest-neighbors, Universal consistency
- Kernels: Representer theorems. Algorithms. Analysis of well-specified models
- Sparsity Inducing Regularizers: L0 penalty. L1 penalty, Recovery Guarantee
- Single hidden layer neural networks: Estimation error, Approximation properties and universality
- Generalization bounds through stochastic gradient descent: Algortithmic Stability, Computational Regularization
- Learning single index models using SGD on neural networks
- Overparametrized models: Benign Overfitting, Tempered Overfitting, High Dimensional Limit
- Community Detection and the Power of Convex Relaxations
- Distribution property testing and estimation

Anant Raj

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

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

Electrical Communication Engineering

Preface

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

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.

Navin Kashyap

Pre-requistes : None

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

E2 207 (AUG) 3 : 0

Concentration Inequalities

Chandra R Murthy , Aditya Gopalan

Pre-requistes : None

References : None

E2 211 (AUG) 3 : 0

Digital Communication

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

Sundar Rajan B

Pre-requistes : None

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

E2 212 (AUG) 3 : 0

Matrix Theory

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

Chandra R Murthy , Sundeep Prabhakar Chepuri

Pre-requistes :

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

E2 221 (AUG) 3 : 0

Communication Networks

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

Parimal Parag

Pre-requistes : None

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

E2 251 (AUG) 3 : 0

Communications Systems Design

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

Chockalingam A

Pre-requistes : None

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

E2 331 (AUG) 3 : 0

Advanced Topics in Coding Theory

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

Sundar Rajan B

Pre-requistes : None

References : None

E3 220 (AUG) 3 : 0

Foundations of Nanoelectronic Devices

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

Kausik Majumdar

Pre-requistes : None

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

E3 237 (JAN) 3 : 0

Integrated Circuits for Wireless Communication

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

Pre-requistes : None

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

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 242 (JAN) 2 : 1

Radio Frequency Integrated Circuits and Systems

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

Pre-requistes : None

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

E8 311 (AUG) 2 : 1

Advanced Topics in Electromagnetics

Vinoy K J

Pre-requistes : None

References : None

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.

E2 237 (AUG) 3 : 0

Statistical Learning Theory

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

Parimal Parag

Pre-requistes **:**
First graduate course in probability theory or equivalent, and instructor's approval.
References : 1. Yury Polyanskiy and Yihong Wu, "Information Theory: From Coding to Learning", Cambridge University Press, forthcoming. 2.Yihong Wu, "Information-theoretic Methods for High-dimensional Statistics", lecture notes. http://www.stat.yale.edu/~yw562/teaching/it-stats.pdf 3.Martin Wainwright, "High-Dimensional Statistics", Cambridge University Press, 2019. 4.Mehryar Mohri, Afshin

E9 247 (AUG) 3 : 1

Learning for 3D Vision and Inverse Graphics

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

Rajiv Soundararajan

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

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

E1 240 (AUG) 3 : 0

Theory of Multi-Armed Bandits

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

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

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

Shubhada Agrawal

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

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

Electrical Engineering

Preface

E1 251 (AUG) 3 : 0

Linear and Nonlinear Optimization

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

Muthuvel Arigovindan

Pre-requistes : None

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

E9 201 (AUG) 3 : 0

Digital Signal Processing

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

Soma Biswas , Prasanta Kumar Ghosh

Pre-requistes : None

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

E9 213 (AUG) 3 : 0

Time-Frequency Analysis

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

Chandra Sekhar Seelamantula

Pre-requistes : None

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

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”

E4 234 (AUG) 3 : 0

Advanced Power Systems Analysis

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

Sarasij Das

Pre-requistes : None

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

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

Pre-requistes : None

References : References: Bernard Hochart, Power Transformer Handbook,Butterworth, 1987.,The J & P Transformer Book,12th Edn, MJ Heathcote, Newnes, 1998. Transformers, Bharat Heavy Electricals Limited, Tata McGraw Hill, 2001.,Blume L F, and Boya Jian, Transformer Engineering, John Wiley and Sons, 1951. Garzon R D, HV Circuit Breakers – Design and Applications,Marcel and Dekker

E6 201 (AUG) 3 : 1

Power Electronics

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

Vishnu Mahadeva Iyer

Pre-requistes : None

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

E8 201 (AUG) 3 : 0

Electromagnetism

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

Udaya Kumar

Pre-requistes : None

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

E9 245 (AUG) 3 : 1

Selected Topics in Computer Vision

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

Srinivasa Venu Madhav Govindu

Pre-requistes : None

References : None

E9 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

E0 298 (AUG) 3 : 1

Linear Algebra and Its Applications

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

Pavankumar Tallapragada , Vaibhav Katewa

Pre-requistes :

none.

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

E6 228 (AUG) 3 : 0

Grid Integration of Inverter-Based Energy Sources

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

Samir Hazra

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

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

E6 240 (AUG) 3 : 0

Multilevel Inverters: Topology and Control

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

Tapas Roy

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

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

Electronic Systems Engineering

Preface

E0 284 (AUG) 2 : 1

Digital VLSI Circuits

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

Viveka Konandur Rajanna

Pre-requistes : None

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

E2 232 (AUG) 2 : 1

TCP/IP Networking

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

Prabhakar T V , Dagale Haresh Ramji

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.

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 282 (AUG) 3 : 0

Basics of Semiconductor Devices and Technology

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

Santanu Mahapatra

Pre-requistes : None

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

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 :
Basic understanding of digital electronic circuits.

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

E3 273 (AUG) 2 : 1

Microcontroller and its Applications

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

Ramachandran P.

Pre-requistes : None

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

Division of Interdisciplinary Sciences

Preface

The Division of Interdisciplinary Research consists of the Centre for Biosystems Science & Engineering, Department of Computational and Data Sciences, Centre for Society and Polity, Interdisciplinary Centre for Energy Research, Interdisciplinary Centre for Water Research, Centre for Nano Science and Engineering, Centre for Infrastructure,Sustainable Transportation and Urban Planning, Department of Management Studies, Robert Bosch Centre for Cyber Physical Systems, Supercomputer Education and Research Centre and Interdisciplinary Mathematical Sciences. The courses offered in the different departments of the Division have been reorganized after review and revision, and have been grouped department wise. These are identified by the following codes.

BE Centre for Biosystems Science & Engineering

CP Robert Bosch Centre for Cyber Physical Systems

ER Interdisciplinary Centre for Energy Research

DS Department of Computational and Data Sciences

MG Department of Management Studies

MS Interdisciplinary Mathematical Sciences

NE Centre for Nano Science and Engineering

UP Centre for Infrastructure,Sustainable Transportation and Urban Planning

The first two digits of the course number have the departmental code as the prefix. The Departments/Centres of the Division provide facilities for research work leading to the degrees of M Tech,M Tech (Research)and PhD. There are specific requirements for completing a Research Training Programme for students registered for research at the Institute. For individual requirements, students are advised to consult the Departmental Curriculum Committee. The M Tech Degree Programmes are offered in Centre for Nano Science and Engineering, Department of Computational and Data Sciences and Robert Bosch Centre for Cyber Physical Systems. Department of Civil Engg and CiSTUP jointly offer an M Tech Programme in Transportation Engineering. Department of Management Studies offers a Master of ManagementProgramme. Most of the courses are offered by the faculty members of the Division, but in certain areas, instruction by specialists in the field and experts from industries are also arranged.

Prof. Navakanta Bhat

Dean

Division of Interdisciplinary Sciences

Society and Policy

Preface

Bioengineering

Preface

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

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

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

BE 203 (AUG) 0 : 1

Bioengineering Practicum 1

Ajay Sanjay Tijore

Pre-requistes : None

References : None

BE 204 (AUG) 0 : 1

Bioengineering Practicum 2

Ajay Sanjay Tijore

Pre-requistes : None

References : None

BE 206 (AUG) 3 : 0

Biology for Engineers

The course provides an introduction to fundamental concepts in Biology for PhD students with little to no knowledge of Biology past 10th or 12th standard school curriculum. The course will cover the following topics: biomolecules,fundamentals of biochemistry,protein structure and function, basic molecular biology,genetics,and an introduction to the cellular architecture. A combination of theoretical concepts and basic experimental methodologies in biology will be discussed. In addition, an introduction to how cells form tissues will be covered, which includes lectures on classification of tissues.The concepts covered here will aid in the skill development required to study diverse problems in bioengineering.

Rachit Agarwal , Ajay Sanjay Tijore

Pre-requistes : None

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

BE 210 (AUG) 3 : 0

Drug Delivery: Principles and Applications

The course provides an introduction to fundamental concepts in Biology for PhD students with little to no knowledge of Biology past 10th or 12th standard school curriculum. The course will cover the following topics: biomolecules,fundamentals of biochemistry, protein structure and function, basic molecular biology, genetics, and an introduction to the cellular architecture. A combination of theoretical concepts and basic experimental methodologies in biology will be discussed. In addition, an introduction to how cells form tissues will be covered, which includes lectures on classification of tissues.The concepts covered here will aid in the skill development required to study diverse problems in bioengineering. This course introduces concepts of drug delivery to meet medical challenges.The course is designed to be modular, with each module focusing on the following topics: Diffusion and permeation of drugs in biological systems;Pharmacokinetics and pharmacodynamics; Challenges and stra

Rachit Agarwal

Pre-requistes : None

References : Biology: Concepts and Connections, Third Edition. Campbell, Mitchell and Reece.~Molecular Biology of the Cell, Fourth Edition. B.Alberts,A. Johnson, J.Lewis, M.Raff, K.Roberts and P. Walter Drug Delivery: Engineering Principles for Drug Therapy,W.Mark Saltzman,Oxford University Press, 2001~Drug Delivery:Fundamentals and Applications,Anya M.Hillery and Kinam Park

BE 213 (AUG) 2 : 0

Fundamentals of Bioengineering 1

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

Bhushan J Toley

Pre-requistes : None

References : None

BE 214 (AUG) 2 : 0

Fundamentals of Bioengineering 2

This course covers essentials of biomaterials and cell and tissue mechanics. It caters to those who want to get first exposure to the topics, which lays the foundation for advanced courses in these two topics.

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

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

Rachit Agarwal , Medhavi Vishwakarma

Pre-requistes : None

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

Nanoscience and Engineering

Preface

NE 200 (AUG) 2 : 0

Technical Writing and Presentation

This course is designed to help students learn to write their manuscripts,technical reports, and dissertations in a competent manner. The do's and dont's of the English language will be dealt with as a part of the course. Assignments will include writing on topics to a student's research interest,so that the course may benefit each students directly.

Supradeepa V R

Pre-requistes : None

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

NE 202 (AUG) 0 : 2

Micro AND Nano Fabrication

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

Sushobhan Avasthi

Pre-requistes :
NE203 or NE203A

References : None

NE 215 (AUG) 3 : 0

Applied Solid State Physics

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

Chandan Kumar

Pre-requistes : None

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

NE 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.

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 313 (AUG) 3 : 0

Lasers: Principles and Systems

This is an intermediate level optics course which builds on the background provided in “Introduction to photonics” offered in our de partment. Owing to the extensive use of lasers in various fields, we believe a good understanding of these principles is essential for students in all science and engineering disciplines.

Supradeepa V R , Balaswamy Velpula

Pre-requistes : None

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

NE 314 (AUG) 3 : 0

Semiconductor Opto-electronics and Photovoltaics

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

Aditya Sadhanala

Pre-requistes : None

References : None

NE 281 (AUG) 3 : 0

Statistical and probabilistic data analysis techniques

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

Manoj Varma

Pre-requistes : None

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

NE 240 (AUG) 3 : 0

Materials design principles for electronic, electromechanical and

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

Pavan Nukala

Pre-requistes : None

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

NE 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, oscillos cope/function generator, basics of VNA and small-signal parameters

Akshay K Naik , Gayathri Pillai

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 , Gayathri Pillai

Pre-requistes :

References : Lecture notes

NE 303 (AUG) 2 : 1

Semiconductor Process Integration

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

Sushobhan Avasthi

Pre-requistes :
NE203

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

NE 203A (AUG) 3 : 1

Advanced micro and nanofabrication technology and process

Introduction and overview of micro and nano fabrication technology.Safety and contamination issues in a cleanroom. Overview of cleanroom hazards. Basic process flow structuring. Wafer type selection and cleaning methods. Additive fabrication processes. Material deposition methods. Overview of physical vapour deposition methods (thermal, e-beam, molecular beam evaporation) and chemical vapour deposition methods(PE-CVD, MOCVD, CBE, ALD). Pulsed laser deposition (PLD), pulsed electron deposition (PED). Doping: diffusion and ion implant techniques.Optical lithography fundamentals, contact lithography,stepper/ canner lithography, holographic lithography, direct-laser writing.Lithography enhancement methods and lithography modelling. Non-optical lithography;E-beam lithography, ion beam patterning, bottom-up patterning techniques. Etching process: dry and wet. Wet etch fundamentals,isotropic,directional and anisotropic processes. Dry etching process fundamentals,plasma assisted etch process, Deep Reactive Ion Etching (DRIE), Through Silicon Vias (TSV). Isotropic release etch. Chemical-mechanical polishing (CMP),lapping and polishing. Packaging and assembly, protective encapsulating materials and their deposition. Waferdicing, scribing and cleaving. Mechanical scribing and laser scribing,Wafer bonding, die-bonding. Wire bonding, die-bonding.Chip-mounting techniques. Simulation-based assignments on the above topics

Sushobhan Avasthi

Pre-requistes : None

References : Stephen A. Campbell, The Science and Engineering of Microelectronic Fabrication~Sorab K. Gandhi, VLSI Fabrication Principles: Silicon and Gallium Arsenide~Richard C. Jaeger, Introduction To Microelectronic Fabrication

NE 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 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)

Computational and Data Sciences

Preface

DS 200 (AUG) 0 : 1

Research Methods

This course will develop the soft skills required for the CDS students.The modules (each spanning 3 hours) that each student needs to complete include:Seminar attendance, literature review, technical writing (reading, writing,reviewing), technical presentation, CV/resume preparation, grant writing,Intellectual property generation (patenting), incubation/start-up opportunities, and academia/industry job search.

Debnath Pal

Pre-requistes : None

References : None

DS 201 (AUG) 2 : 0

Bioinformatics

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

Debnath Pal

Pre-requistes : None

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

DS 221 (AUG) 3 : 1

Introduction to Scalable Systems

1) Architecture: computer organization, single-core optimizations including exploiting cache hierarchy and vectorization, parallel architectures including multi-core, shared memory, distributed memory and GPU architectures; 2)Algorithms and Data Structures: algorithmic analysis, overview of trees and graphs, algorithmic strategies, concurrent data structures; 3) Parallelization Principles: motivation, challenges, metrics, parallelization steps, data distribution, PRAM model; Parallel Programming Models and Languages: OpenMP,MPI, CUDA; 4) Big Data Platforms: Spark/MapReduce model, cloud computing. Lab tutorials and programming assignments for above topics.

Sathish S Vadhiyar , Chirag Jain

Pre-requistes : None

References : None

DS 252 (AUG) 3 : 1

Cloud Computing

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

Yogesh L Simmhan

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

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

DS 284 (AUG) 2 : 1

Numerical Linear Algebra

Introduction: Matrix and vector norms, arithmetic and computational complexity, floating point arithmetic. Matrix factorization and direct methods for solving linear systems: Gaussian elimination, LU factorization, Pivoting,Cholesky decomposition, QR factorization, Gram-Schmidt orthogonalization,Projections, Householder reflectors, Givens rotation, Singular Value Decomposition, Rank and matrix approximations, image compression using SVD,generalized Schur decomposition (QZ decomposition), Least squares and solution of linear systems and pseudoinverse, normal equations. Stability Analysis:conditioning of a problem, forward and backward stability of algorithms,perturbation analysis. Eigenvalue problems: Gershgorin theorem, Similarity transform, Eigenvalue & eigenvector computations, Power method, Schur decomposition, Jordan canonical form, QR iteration with & without shifts,Hessenberg transformation, Rayleigh quotient, Symmetric eigenvalue problem,Jacobi method, Divide and Conquer, Iter

Phani Sudheer Motamarri

Pre-requistes : None

References : None

DS 288 (AUG) 3 : 0

Numerical Methods

Root finding: Functions and polynomials, zeros of a function, roots of a nonlinear equation, bracketing, bisection, secant, and Newton Raphson methods. Interpolation, splines, polynomial fits, Chebyshev approximation. Numerical Integration and Differentiation: Evaluation of integrals, elementary analytical methods, trapezoidal and Simpson’s rules, Romberg integration,Gaussian quadrature and orthogonal polynomials, multidimensional integrals,summation of series, Euler-Maclaurin summation formula, numerical differentiation and estimation of errors. Optimization: Extremization of functions, simple search, Nelder-Mead simplex method, Powell’s method,gradient-based methods, simulated annealing. Complex analysis: Complex numbers, functions of a complex variable, analytic functions, conformal mapping ,Cauchy’s theorem. Calculus of residues. Fourier and Laplace Transforms,Discrete Fourier Transform, z transform, Fast Fourier Transform (FFT),multidimensional FFT, basics of numerical optimizat

Ratikanta Behera

Pre-requistes : None

References : None

DS 215 (AUG) 3 : 0

Introduction to Data Science

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

Anirban Chakraborty

Pre-requistes :
Undergraduate level knowledge of linear algebra, multivariate calculus, numerical methods, basic programming skills (in any programming
References : 1. Athanasios Papoulis and S. Unnikrishna Pillai, Probability, Random Variables and Stochastic Processes, McGraw Hill Education, 2017. 2. Alberto Leon-Garcia, Probability, Statistics, and Random Processes for Electrical Engineering, 3rd Edition, Pearson, 2008. 3. Steven M. Kay, Fundamentals of Statistical Signal Processing, Volume I: Estimation Theory, Pearson, 1993. 4. Jerome H.

DS 307 (AUG) 3 : 0

Ethics In AI

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

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

Danish Pruthi

Pre-requistes :

The class is intended for graduate students and senior
References : 1. Fairness and Machine Learning: Limitations and Opportunities by Solon Barocas, Moritz Hardt, Arvind Narayanan

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

DS 363 (AUG) 3 : 1

Topics in Visual Analytics

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

Anirban Chakraborty

Pre-requistes :

A first course in data analysis or machine learning (e.g., DS 216,

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

DS 246 (AUG) 1 : 2

Generative AI in Practice

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

Sashikumaar Ganesan

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

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

Management Studies

Preface

MG 261 (AUG) 3 : 0

Operations Management

Introduction to Production/Operations Management (P/OM), P/OM strategy, forecasting, process management, facility layout, capacity planning and facility planning, aggregate planning, material requirement planning, scheduling, inventory management, waiting line, project management, management of quality. Introduction to simulation and to supply chain management.

Mathirajan M

Pre-requistes : None

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

MG 201 (AUG) 3 : 0

Managerial Economics

Introduction to managerial economics, demand theory and analysis, productiontheory, cost theory, market structure and product pricing, Pricing of goods and services, pricing and employment of inputs. Micro and macro economics,national income accounting, GDP measurement, inflation and price level,aggregate demand and supply, fiscal and monetary policy.

Bala Subrahmanya Mungila Hillemane

Pre-requistes : None

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

MG 202 (AUG) 3 : 0

Macroeconomics

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

Bala Subrahmanya Mungila Hillemane

Pre-requistes : None

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

MG 212 (AUG) 2 : 1

Behavioral Science

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

Anjula Gurtoo

Pre-requistes : None

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

MG 225 (AUG) 3 : 0

Decision Models

Analytical hierarchy process: structuring of a problem into a hierarchy consisting of a goal and subordinate features of the problem, and pairwise comparisons between elements at each level. Goal programming: Pareto optimality, soft constraints, identifying the efficient frontier, duality and sensitivity analysis. Data envelopment analysis: relative efficiency measurements, DEA model and analysis, graphical representation, and dual DEA model. Agent based modeling: complex adaptive systems, emergent structures and dynamic behaviors. Discrete event simulation: random number generators and generating random variates. Selecting input probability distributions and output data analysis. Neural networks: neuron model and network architecture, perceptron learning rule, and back propagation. Support vector machines: Learning methodology, linear learning machines, kernel-induced feature spaces.

Parthasarathy Ramachandran

Pre-requistes : None

References : None

MG 241 (AUG) 3 : 0

Marketing Management

Marketing function, marketing concept, relationship with other functions,relevance, marketing environment, markets. Consumer behavior, market segmentation, marketing planning, marketing mix, Product policy, new products,product life cycle. Pricing, distribution. Advertising and promotion.Marketing organization. Sales forecasting. Management of sales force,marketing control.

Shashi Jain

Pre-requistes : None

References : None

MG 251 (AUG) 3 : 0

Finance and Accounts

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

Shashi Jain

Pre-requistes : None

References : None

MG 265 (AUG) 3 : 0

Data Mining

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

Parthasarathy Ramachandran

Pre-requistes : None

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

MG 229 (AUG) 3 : 0

Regression and Time Series Analysis

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

Mukhopadhyay C

Pre-requistes : MG220 or equivalent

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

MG 219 (AUG) 3 : 0

Introductory Probability Theory

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

Mukhopadhyay C

Pre-requistes : Multivariable Calculus and Linear Algebra

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

Energy Research

Preface

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

ER 201 (AUG) 3 : 0

Renewable Energy Technologies

Energy is a critical component in the daily life of mankind. Historically, energy production technologies have shown a continual diversification depending on technological, social, economical, and even political impacts. In recent times, environmental and ecological issues have also significantly affected the energy usage patterns. Hence, renewable energy sources are occupying increasingly important part of the emerging energy mix. This course gives an introduction to key renewable energy technologies. Case studies will be discussed to emphasize the applications of renewable energy technologies. At the end of the course students should be able to identify where, how and why renewable energy technologies can be applied in practice.

Aninda Jiban Bhattacharyya

Pre-requistes : None

References : None

ER 209 (AUG) 3 : 0

Introduction to Scientific Communication

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

Farsa Ram

Pre-requistes : None

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

Water Research

Preface

Cyber Physical Systems

Preface

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

Transportation and Urban Planning

Preface

SL 222 (AUG) 3 : 1

Transportation Demand and Supply Modeling

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

Abdul Rawoof Pinjari

Pre-requistes : None

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

SL 225 (AUG) 3 : 1

Logistics and Freight Modeling

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

Tarun Rambha

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

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

Division of Mechanical Sciences

Preface

The Division of Mechanical Sciences consists of the departments of Aerospace Engineering, Atmospheric and Oceanic Sciences, Civil Engineering, Chemical Engineering, Divecha Centre for Climate Change, Earth Sciences, Mechanical Engineering, Materials Engineering, Product Design and Manufacturing, and Sustainable Technology. It also maintains an Advanced Facility for Microscopy and Microanalysis (AFMM) and manages the Space Technology Cell (STC). The courses offered in different departments of the Division have been reorganized after review and revision. These are identified by the following codes.

AE Aerospace Engineering

AS Atmospheric and Oceanic Sciences

CE Civil Engineering

CH Chemical Engineering

DC Divecha Centre of Climate Change

ER Earth Sciences

ME Mechanical Engineering

MT Materials Engineering

PD Product Design and Manufacturing

ST Sustainable Technologies

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

Prof. G. K. Ananthasuresh

Dean

Division of Mechanical Sciences

Aerospace Engineering

Preface

AE 202 (AUG) 3 : 0

Fluid Dynamics

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

Rishita Das

Pre-requistes : None

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

AE 203 (AUG) 3 : 0

Mechanics and Thermodynamics of Propulsion

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

Sivakumar D

Pre-requistes : None

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

AE 205 (AUG) 3 : 0

Navigation, Guidance and Control

Navigation: Continuous waves and frequency modulated radars, MTI and Doppler radars; Hyperbolic navigation systems: INS, GPS, SLAM; Guidance: Guided missiles, guidance laws: pursuit, LOS and PN laws, Guidance of UAVs; Control: Linear time invariant systems, transfer functions and state space modeling,analysis and synthesis of linear control systems, applications to aerospace engineering.

Radhakant Padhi

Pre-requistes : None

References : AE NGC Faculty, Lecture Notes.~Skolnik, M. I., Introduction to Radar Systems,2 nd edition, McGraw Hill Book Company~Bose A., Bhat, K. N., Kurian T.,Fundamentals of Navigation and Inertial Sensors, 1st edition, Prentice-Hall India.~Noureldin, A., Karamat, T. B.,and Georgy, J., Fundamentals of Inertial Navigation, Satellite-based Positioning and their Integration, 1st edition ,

AE 206 (AUG) 3 : 0

Hypersonic Flow Theory

Srisha Rao M V

Pre-requistes : None

References : None

AE 211 (AUG) 3 : 0

Mathematical Methods of Aerospace Engineers

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

Ramesh O N

Pre-requistes : None

References : Erwin Kreysig, Advanced Engineering Mathematics Wiley 2015.

AE 245 (AUG) 3 : 0

Advanced Combustion

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

Pratikash Prakash Panda

Pre-requistes : None

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

AE 261 (AUG) 3 : 0

Structural Vibration Control

Introduction to modal testing and applications, Frequency Response Function (FRF) measurement, properties of FRF data for SDOF and MDOF systems, signal and system analysis, modal analysis of rotating structures; exciters, sensors application in modal parameter (natural frequency, damping and mode shape)estimation. Vibration standards for human and machines, calibration and sensitivity analysis in modal testing, modal parameter estimation methods,global modal analysis methods in time and frequency domain, derivation of mathematical models– modal model, response model and spatial models. Coupled and modified structure analysis. Application of modal analysis to practical structures and condition health monitoring. Introduction to vibration control, passive and active vibration control. Concept of vibration isolation, dynamic vibration absorber, visco- elastic polymers as constrained and unconstrained configuration in passive vibration control. Constitutive modeling of structures with PZ

Siddanagouda Kandagal

Pre-requistes : None

References : Ewins, D.J., Modal analysis: Theory and Practice, Research Studies Press Ltd., England, 2000.~Clarence W. de Silva, Vibration: Fundamentals and Practice, CRC press New York, 1999~G. McConnel, Vibration testing: Theory and Practice, John Wiley & Sons, Inc., New York, 1995. Nashif, D.N., Jones, D.I.G., and Henderson, J.P., Vibration damping, John Wiley, New York,

AE 296 (AUG) 0 : 1

Experimental Techniques in Aerospace Engineering

Experimental techniques in aerospace engineering is a 0:1 credit course that will include demonstrations of experiments in the major sub-disciplines of aerospace engineering. The intent of this course is to give an overview of the experimental facilities and techniques that are commonly used in research in aerospace.

Debiprosad Roy Mahapatra

Pre-requistes : None

References : None

AE 372 (AUG) 3 : 0

Applied optimal Control and State Estimation

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

Radhakant Padhi , Ravi Prakash

Pre-requistes : None

References : Naidu, D.S., Optimal Control Systems, CRC Press, 2002.~Sinha, A., Linear Systems: Optimal and Robust Control, CRC Press, 2007~Bryson, A.E., and Ho, Y-C, Applied Optimal Control, Taylor and Francis, 1975.~Stengel, R.F., Optimal Control and Estimation, Dover Publications, 1994.~Sage, A.P., and White, C.C. III, Optimum Systems Control, 2nd Ed., Prentice Hall, 1977.~Kirk, D.E.,

AE 204A (AUG) 3 : 0

Mechanics of Flight Vehicle Structures

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

Kartik Venkatraman , Vivekanand Dabade

Pre-requistes : None

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

Atmospheric and Oceanic Sciences

Preface

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

Sustainable Technologies

Preface

ST 210 (AUG) 3 : 1

Principles and Applications of GIS and Remote Sensing

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

Ramachandra T V

Pre-requistes : None

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

ST 214 (AUG) 3 : 0

Mathematical Analysis of Experimental Data

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

Lakshminarayana Rao M P

Pre-requistes : None

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

ST 217 (AUG) 3 : 1

Field hydrology, river engineering and basin studies

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

Punit Singh

Pre-requistes : None

References : [1] Barenblatt. G. I, 'Scaling', Cambridge Texts in Applied Mathematics, (2003) [2] Holman J. P., Experimental Methods for Engineers, Mcgraw-Hill Series in Mechanical Engineering, Eight Edition, (2011) [3] Grinstead M. C., Snell L. J., 'Introduction to Probability', 'American Mathematical Society', (1991) [4]Moffat, R. J., 'Contributions to the Theory of Single-Sample Uncertainty Analysis', J. Fluids

ST 219 (AUG) 3 : 0

Separation Technologies for Sustainable Industrial Processes

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

Yagnaseni Roy

Pre-requistes : None

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

ST 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 harvesting. Surface, ground & rainwater quality. Contamination scenarios & need for treatment. Drinking water treatment & requirements. Other remediation techniques. Industrial water treatment & requirements. Seawater desalination. Wastewater quantity & quality, parameters. Water pollution, hazards & need for wastewater treatment. Conventional wastewater treatment. Resource recovery options. Recycling of treated wastewater. Options for industrial wastewater treatment.

Sreenivasan Ramaswami

Pre-requistes : None

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

ST 225 (AUG) 3 : 0

Sustainable Materials

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

Navneet Kumar Gupta

Pre-requistes : None

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

ST 224 (AUG) 3 : 0

Renewable energy

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

Lakshminarayana Rao M P , Navneet Kumar Gupta

Pre-requistes : None

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

Chemical Engineering

Preface

CH 201 (AUG) 3 : 0

Engineering Mathematics

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

Prabhu R Nott , Ananth Govind Rajan

Pre-requistes : None

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

CH 202 (AUG) 3 : 0

Numerical Methods

Basics of scientific computing, basics of Matlab programming, solutions of linear algebraic equations, eigenvalues and eigenvectors of matrices, solutions of nonlinear algebraic equations, Newton-Raphson methods, function approximation, interpolation, numerical differentiation and integration,solutions of ordinary differential equations – initial and boundary value problems, solutions of partial differential equations, finite difference methods, orthogonal collocation.

Bhushan J Toley

Pre-requistes : None

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

CH 203 (AUG) 3 : 0

Transport Processes

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

Kumaran V , Ananth Govind Rajan

Pre-requistes : None

References : Bird, R.B, Stewart, W.E. and Lightfoot, E.N., Transport Phenomena, Wiley, 1994.~L. G. Leal, Luminar Flow and Convective Transport Processes, Butterworth Heineman, 1992.

CH 204 (AUG) 3 : 0

Thermodynamics

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

Sudeep 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 242 (AUG) 3 : 0

Special Topics in Theoretical Biology

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

Narendra M Dixit

Pre-requistes : None

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

CH 255 (AUG) 3 : 0

Introduction to Polymer Science

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

Nirmalya Bachhar

Pre-requistes : None

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

Civil Engineering

Preface

CE 201 (AUG) 3 : 0

Basic Geo-mechanics

Introduction to genesis of soils, basic clay mineralogy; Principle of effective stress, permeability and flow; Fundamentals of Tensors, Introductionto stresses and deformation measures; Mohr-Coulomb failure criteria, soil laboratory tests; Critical state and stress paths. Shear Strength and Stiffness of Sands; Consolidation, shear strength and stiffness of clays

Tejas Gorur Murthy

Pre-requistes : None

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

CE 204 (AUG) 3 : 0

Solid Mechanics

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

Ananth Ramaswamy

Pre-requistes : None

References : Fung Y. C. and Pin Tong, Classical and Computational Solid Mechanics, World Scientific, 2001~Boresi, A.P., Chong K., and Lee J., Elasticity in Engineering Mechanics, Wiley, 2010~Theoretical Elasticity, A.E. Green and W. Zerna, 1968,Dover Publications~Malvern L., Introduction to the Mechanics of a Continuous Medium, Prentice Hall, 1969

CE 211 (AUG) 3 : 0

Mathematics for Engineers

Revision of ordinary linear ODEs, Formal operators, Adjoint operator, Sturm-Liouville theory, eigenvalue problems, Classification of PDEs, Characteristics / first order PDEs, Laplace equation / potential theory, Separation of variables (cartesian, polar), Eigenfunction expansions, Green's functions, Introduction to boundary value problems Probability space and axioms of probability. Conditional probability. Total probability and Bayes theorems. Scalar and vector random variables. Probability distribution and density functions. Expectation operator. Functions of random variables. Vector spaces and subspaces, solution of linear systems, Linear independence,basis, and dimension, The four fundamental subspaces, Linear transformations,Orthogonal vectors and subspaces, Cosines and projections onto lines,Projections and least squares, The fast Fourier transform, Eigenvalues and eigenvectors, Diagonalization of a matrix, Difference equations and powers of matrices, Similarity transformation

Chandra Kishen J M , Debraj Ghosh

Pre-requistes : None

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

CE 220 (AUG) 3 : 0

Design of Substructures

Design considerations, field tests for bearing capacity and settlement estimates, selection of design parameters. Structural design considerations.Codes of practice. Design of spread footings, combined footings, strap footings, ring footings, rafts, piles and pile caps and piers.

Raghuveer Rao Pallepati

Pre-requistes : None

References : Bowles,J.E. Foundation analysis and design. 5th Edn.,McGraw Hill,1996 ~Indian Standard Codes

CE 221 (AUG) 3 : 0

Earthquake Geotechnical Engineering

Introduction to engineering seismology. Plate tectonics. Earthquake magnitude. Ground motion. Effect of local soil conditions on ground motion. Dynamic behaviour of soils. Analysis of seismic site response. Liquefaction phenomena and analysis of pore pressure development. Laboratory and in-situ testing for seismic loading. Analysis and design of slopes, embankments, foundations and earth retaining structures for seismic loading. Case histories. Mitigation techniques and computer- aided analysis

Gali Madhavi Latha

Pre-requistes : None

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

CE 228N (AUG) 3 : 0

Introduction to the Theory of Plasticity

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

Narayan K Sundaram

Pre-requisites :
None, but a background grad-level solid mechanics course (CE 204 or ME 242) is strongly recommended.

References : Plasticity Theory - J. Lubliner
Plasticity for Engineers - C. R. Calladine
Theory of Plasticity - J. Chakrabarty

CE 274 (AUG) 3 : 0

Earthquake Resistant Design

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

Chandra Kishen J M

Pre-requisites : None

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

CE 217 (AUG) 3 : 0

Fluid Mechanics

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

Debsunder Dutta

Pre-requistes : None

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

CE 260 (AUG) 3 : 0

Rock Mechanics

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

Jyant Kumar

Pre-requistes : None

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

CE 207A (AUG) 3 : 0

Characterization of Bituminous Materials

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

Satyavati Komaragiri

Pre-requistes :

None

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

CE 209A (AUG) 3 : 0

Elastic Wave Propagation and Applications in NDE

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

Vivek Samu

Pre-requistes : None

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

CE 210A (AUG) 3 : 0

Thermodynamic Modelling of Cementitious Systems

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

Keshav Bharadwaj Ravi

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

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

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 231 (AUG) 3 : 0

Interfacial Phenomena in Materials Processing

Ashok M Raichur

Pre-requistes : None

References : None

MT 250 (AUG) 3 : 0

Introduction to Materials Science and Engineering

Subodh Kumar

Pre-requistes : None

References : None

MT 253 (AUG) 3 : 0

Mechanical Behaviour of Materials

Theory of Elasticity. Theory of Plasticity. Review of elementary dislocationtheory. Deformation of single and polycrystals. Temperature and Strain rate effects in plastic flow. Strain hardening, grain size strengthening, solid solution strengthening, precipitation strengthening, dispersion strengthening.martensitic strengthening. Creep, fatigue and fracture.

Praveen Kumar

Pre-requistes : None

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

MT 261 (AUG) 3 : 0

Organic Electronics

Fundamentals of polymers. Device and materials physics. Polymer electronicsmaterials, processing, and applications. Chemistry of device fabrication,materials characterization. Electroactive polymers. Device physics: Crystal structure, Energy band diagram, Charge carriers, Heterojunctions, Diode characteristics. Device fabrication techniques: Solution, Evaporation,electrospinning. Devices: Organic photovoltaic device, Organic light emitting device, Polymer based sensors.Stability of organic devices.

Praveen Ramamurthy

Pre-requistes : None

References : T. A. Skotheim and J. R. Reynolds (Editors): Handbook of Conducting Polymers (Third Edition) Conjugated Polymers: Theory, Synthesis, Properties and Characterization, CRC Press.~T.A. Skotheim and J. R. Reynolds (Editors): Handbook of Conducting Polymers (Third Edition) Conjugated Polymers:Processing and Applications Edited by Terje A. Skotheim and John R. Reynolds,CRC

MT 271 (AUG) 3 : 0

Introduction to Biomaterials Science and Engineering

This course will introduce basic concepts of biomaterials research and development including discussion on different types of materials used for biomedical applications and their relevant properties. Content: Surface engineering for biocompatibility; Protein adsorption to materials surfaces;Blood compatibility of materials; Immune response to materials; Corrosion and wear of implanted medical devices; Scaffolds for tissue engineering and regenerative medicine; Concepts in drug delivery;

Kaushik Chatterjee

Pre-requistes : None

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

MT 245 (AUG) 3 : 0

Transport Processes in Process Metallurgy

Basic and advanced idea of fluid flow, heat and mass transfer. Integral mass, momentum and energy balances. The equations of continuity and motion and its solutions. Concepts of laminar and turbulent flows. Concept of packed and fluidized bed. Non-wetting flow, Natural and forced convection. Unit processes in process metallurgy. Application of the above principles in process metallurgy.

Govind S Gupta

Pre-requistes : None

References : J. Szekely and N.J. Themelis, Rate Phenomena in Process Metallurgy, Wiley, New York, 1971~G.H. Geiger and D R Poirier: Transport Phenomena in Metallurgy, Addison-Wesley, 1980.~D.R. Gaskell: Introduction to Transport Phenomena in Materials Processing, 1991.~R.B. Bird, W.E. Stewart and E.N. Lightfoot: Transport Phenomena, John Wiley International Edition, 1960~F.M. White: Fluid

MT 240 (AUG) 3 : 0

Principles of Electrochemistry and Corrosion

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

Naga Phani B Aetukuri , Sai Gautam Gopalakrishnan

Pre-requistes : Basic knowledge in materials thermodynamics

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

MT 211 (AUG) 3 : 0

Magnetism, Magnetic Materials, and Devices

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

Bhagwati Prasad

Pre-requistes : None

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

MT 217 (AUG) 3 : 0

Computational Mathematics for Materials Engineers

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

Abhik N Choudhury , Pikee Priya

Pre-requistes : None

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

MT 204 (AUG) 3 : 0

Structure and Properties of Materials

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

Karthikeyan Subramanian , Rajeev Ranjan

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

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

MT 273 (AUG) 3 : 0

Semiconductor Films: Deposition and Spectroscopic Characterization

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

Sachin R Rondiya

Pre-requistes : None

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

MT 310 (AUG) 3 : 0

Manufacturing Process modelling

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

Prosenjit Das

Pre-requistes : Introduction to Manufacturing Science MT 309

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

MT 312 (AUG) 3 : 0

Polymer Engineering and Sustainable Materials

Polymer Science and Engineering Fundamentals
Introduction to polymers, polymer blends and composites, nanostructured materials and nanocomposites. Polymer-polymer miscibility, factors governing miscibility, immiscible systems and phase separation. Importance of interface on the property development, compatibilizers and compatibilization. Blends of amorphous & semi-crystalline polymers, rubber toughened polymers, particulate, fiber reinforced composites.
Nanocomposites and Interface Engineering
Nanostructured materials like nano clay, carbon nanotubes, graphene etc. and polymer nanocomposites. Surface treatment of the reinforcing materials and interface/interphase structures of composites/ nanocomposites.
Processing and Properties
Various processing techniques like solution mixing, melt processing. Unique properties of blends, composites/nanocomposites in rheological, mechanical, and physical properties and applications.
Sustainable Polymers: Recycling, Circular Economy, and Advanced Materials
polymer lifecycle, its environmental impact, and the shift from a linear to a circular economy, emphasizing principles like reduce, reuse, and recycle. We'll explore mechanical and chemical recycling technologies, including advanced methods like depolymerization and pyrolysis, alongside strategies for design for recyclability. A significant segment focuses on vitrimers, examining their unique chemistry, synthesis, processing, and role in creating self-healing and highly recyclable materials. bioplastics and compostable plastics.

Suryasarathi Bose

Pre-requisites : None

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

Mechanical Engineering

Preface

ME 201 (AUG) 3 : 0

Fluid Mechanics

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

Ratnesh K Shukla , Balachandra Suri

Pre-requistes : None

References : None

ME 242 (AUG) 3 : 0

Solid Mechanics

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

Chandrashekhar S Jog

Pre-requistes : None

References : None

ME 243 (AUG) 3 : 0

Continuum Mechanics

Analysis of stress, analysis of strain, stress-strain relations, two-dimensional elasticity problems, airy stress functions in rectangular and polar coordinates, axisymmetric problems, energy methods, St. Venant torsion,elastic wave propagation, elastic instability and thermal stresses.
Introduction to vectors and tensors, finite strain and deformation-Eulerian and Lagrangian formulations, relative deformation gradient, rate of deformation and spin tensors, compatibility conditions, Cauchy's stress principle, stress tensor,conservation laws for mass, linear and angular momentum, and energy. Entropy and the second law, constitutive laws for solids and fluids, principle of material frame indifference, discussion of isotropy,linearized elasticity, fluid mechanics.

Chandrashekhar S Jog

Pre-requistes : None

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

ME 246 (AUG) 3 : 0

Introduction to Robotics

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

Jishnu Keshavan

Pre-requistes : None

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

ME 250 (AUG) 3 : 0

Structural Acoustics

Vibration and acoustic response of an infinite plate in contact with an acoustic half space to a line force (Crighton’s solution). Complex variables,integration with branch cuts. Fluid-structure coupling in 2-D flexible-walled waveguides using asymptotic expansions (rectangular and cylindrical geometries). Coupling of sound with flexible enclosures. Sound radiation from finite rectangular plates and cylindrical shells. Transform and Rayleigh integral methods. Coincidence and wave number spectra, wave impedance, radiation efficiency.

Venkata R Sonti

Pre-requistes : None

References : None

ME 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 259 (AUG) 3 : 0

Nonlindear Finite Element Methods

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

Narasimhan R

Pre-requistes : None

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

ME 261 (AUG) 3 : 0

Engineering Mathematics

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

Venkata R Sonti , Shubhadeep Mandal , Akshay Joshi

Pre-requistes : None

References : None

ME 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 297 (AUG) 1 : 0

Departmental Seminar

The student is expected to attend and actively take part in ME departmental seminars for one semester during his/her stay.

Shubhadeep Mandal

Pre-requistes : None

References : None

ME 260 (AUG) 3 : 0

Structural Optimiztion:Size, Shape, and Topology

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

Ananthasuresh G K

Pre-requistes : None

References : NPTEL MOOC:https://nptel.ac.in/courses/112/108/112108201/~Haftka, R.T. and Gurdal, Z., "Elements of Structural Optimization," Kluwer Academic Publishers,1992.~Bendsoe, M. P. and Sigmund, O., "Topology Optimization: Theory, Methods, and Applications," Springer, 2003.~Haug, E. J., Choi, K.K., and Komkov, V.,“Design Sensitivity Analysis of Structural Systems, ”Academic

ME 207 (AUG) 3 : 0

Capillarity and Interfacial Phenomenon

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

Susmita Dash

Pre-requistes :

Undergraduate fluid mechanics

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

ME 278 (AUG) 3 : 0

A practical introduction to data analysis

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

Navaneetha Krishnan Ravichandran , Balachandra Suri

Pre-requistes : None

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

ME 262 (AUG) 3 : 0

Wave Propagation in Solids

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

Debashish Das , Akshay Joshi

Pre-requistes :

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

Dept. of Design and Manufacturing

Preface

MN 202 (AUG) 3 : 0

Digital Manufacturing

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

Dibakar Sen

Pre-requistes : None

References : None

PD 201 (AUG) 2 : 1

Elements of Design

Visual language, visual elements, visual perception, visual deception. Universal principles of design. Theory of colour, studies in form, graphic compositions, grid structure, spatial analysis and organization. Visual expressions in nature.

Vishal Singh

Pre-requistes : None

References : Young, F.M., Visual Studies, Prentice-Hall, USA.,Lidwell, W.,Holden, K., and Butler, J., Universal Principles of Design,Rockport,USA.,Evans, P., and Thomas, M., Exploring the Elements of Design,Thomson, USA.

PD 231 (AUG) 2 : 1

Applied Ergonomics

Introduction to ergonomics. Elements of anthropometry, physiology, anatomy,biomechanics and CTDs. Workspace, seating, hand tool design, manual material handling. Man-machine system interface, human information processing, displays and controls, compatibility. Environmental factors, cognitive ergonomics,principles of graphic user interface design, human error, product safety,product liability.

Dibakar Sen

Pre-requistes : None

References : Sanders and McCormick,Human Factors in Engineering and Design,Seventh Edn,McGraw Hill

PD 234 (AUG) 2 : 1

Intelligent User Interface

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

Pradipta Biswas

Pre-requistes : None

References : Shneiderman B. "Designing The User Interface - Strategies for Effective Human-Computer Interaction.",Buxton B., Sketching User Experiences: Getting the Design Right and the Right Design, Morgan Kaufmann,Norman K (Ed), Wiley Handbook of Human Computer Interaction, Wiley 2017

PD 204 (AUG) 2 : 1

Basics of Electronics for Product Design and Manufacturing

Introduction to sensors and actuators, Static vs. current electricity, Passive and active components of electrical systems, Type of electrical sources, Introduction to linear and non-linear electrical components, Basic circuit theory and analysis of DC circuits, Basics of AC circuit, Basics of power distribution, domestic and industrial electrical wiring and safety, AC-AC and AD-DC conversion, Voltage regulator, Constant current source, Sensor biasing (voltage vs. current biasing) and transduction, Transistors: Type and application as amplifier and switch, Basic op-amp circuit, Introduction to digital logic, Combinational and sequential circuit, Discrete signals: Number systems and binary arithmetic, Logic gates, Flip-Flops, Sampling theory, Sampling and hold circuit, anti-aliasing filter, Digital to Analog (DAC) and Analog to Digital (ADC)Conversions, Different types of ADC and DAC with their benefits and limitations, Basics of Microprocessors and microcontrollers. Introduction to sens

Abhijit Biswas

Pre-requistes : Students without electrical or electronics or instrumentation or similar background perusing higher study in interdisciplinary fields

References : •Roy Choudhury, D. (1988). Networks and Systems. India: Wiley Eastern. •Jain, B., Jain, S., Roy Choudhury, D.(2010).Linear Integrated Circuits. United Kingdom: New Age Science Limited. •M.Morris Mano and Michael D. Ciletti, Digital Design, Pearson, Prentice Hall, https://archive.org/details/morrismano4thedition/page/n 1/mode/2up •Dam, B. v. (2009). Microcontroller Systems Engineering:45

PD 206 (AUG) 2 : 1

Basics of Computing, AI and Data Science for Design and Manufacturing

Introduction to sensors and actuators, Static vs. current electricity, Passive and active components of electrical systems, Type of electrical sources, Introduction to linear and non-linear electrical components, Basic circuit theory and analysis of DC circuits, Basics of AC circuit, Basics of power distribution, domestic and industrial electrical wiring and safety, AC-AC and AD-DC conversion, Voltage regulator, Constant current source, Sensor biasing(voltage vs. current biasing) and transduction, Transistors: Type and application as amplifier and switch, Basic op-amp circuit, Introduction to digital logic, Combinational and sequential circuit, Discrete signals:Number systems and binary arithmetic, Logic gates, Flip-Flops, Sampling theory, Sampling and hold circuit, anti-aliasing filter, Digital to Analog (DAC) and Analog to Digital (ADC)Conversions, Different types of ADC and DAC with their benefits and limitations, Basics of Microprocessors and microcontrollers.

Abhijit Biswas

Pre-requistes : Students without computer science or data science or information technology or similar background perusing higher study in interdisc

References : •Roy Choudhury, D. (1988). Networks and Systems. India: Wiley Eastern. •Jain, B., Jain, S., Roy Choudhury, D.(2010).Linear Integrated Circuits. United Kingdom: New Age Science Limited. •M.Morris Mano and Michael D. Ciletti, Digital Design, Pearson, Prentice Hall, https://archive.org/details/morrismano4thedition/page/n 1/mode/2up •Dam, B. v. (2009). Microcontroller Systems Engineering:45

Mobility Engineering

Preface

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

High Energy Physics

Preface

HE 392 (AUG) 3 : 0

String Theory

"Bosonic Strings: closed and open, oriented and unoriented. Light cone quantization and spectrum. Polyakov path integral. BRST symmetry. Conformal field theory. Modular invariance. Boundary states. Classical and quantum superstrings. Spin structures and GSO projection. Type II strings. D-branes and Type I strings. Torus compactification and Heterotic strings.Current algebras and lattices. Bosonization. N=1,2 superconformal field theory. "

Chethan Krishnan

Pre-requistes : None

References : "Green M.B., Schwarz J.H. and Witten E., Superstring Theory, Vol. I and II,Cambridge University Press, 1989.Polchinski J., String Theory, Vol I and II,Cambridge University Press, 2005.Kiritsis E., String Theory in a Nutshell,Princeton University Press, 2007. "

HE 395 (AUG) 3 : 0

Quantum Field Theory - I

Scalar, spinor and vector fields. Canonical quantisation, propagators. Symmetries and Noether theorem. Path integrals for bosonic and fermionic fields, generating functionals. Feynman diagrams. Klein-Gordon and Dirac equations. Discrete symmetries:P,C,T. S-matrix, LSZ reduction formula.Interacting scalar and Yukawa theories. Scattering cross-sections, optical theorem, decay rates. Loop diagrams, power counting, divergences. Renormalization, fixed point classification.One loop calculations. Callan-Symanzik equations, beta functions. Effective field theory.

Prasad Satish Hegde

Pre-requistes : None

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

HE 398 (AUG) 3 : 0

General Relativity

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

Sachindeo Vaidya

Pre-requistes : None

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

HE 379 (AUG) 3 : 0

Physics Beyond Standard Model

Higgs discovery and its implications, effective field theories, supersymmetry and supergravity, extra dimensions and its variants, composite Higgs models, Cosmological solutions like relaxions and its variants, neutrino masses and GUTS, axions, and modern probes of new physics.

Sudhir Kumar Vempati

Pre-requistes :
Advanced graduate students, all qft courses and the Standard Model course.

References :
Csaki's lecture notes, orignial papers.

HE 381 (AUG) 3 : 0

Quantum Field Theory on a Quantum Computer

This course aims to explore the forefront of research in understanding quantum field theory (QFT) through the lens of quantum computing. Students will begin by examining the fundamental principles of QFT, including the quantization of scalar and fermionic fields. Building upon this, we will delve into the discretization of quantum fields on a lattice, which enables the use of computational methods for non-perturbative problems and facilitates quantum simulations. A significant focus will be placed on encoding quantum field theories onto qubits, where techniques such as Jordan-Wigner and Bravyi-Kitaev transformations will be introduced to map fields and interactions onto digital quantum systems. The course will also cover scattering theory within the quantum simulation framework, emphasizing how particle interactions and scattering amplitudes can be studied using quantum algorithms. Additionally, an introduction to continuous-variable quantum computing (CVQC) will be provided, highlighting alternative approaches to quantum simulation that utilize bosonic modes and CV gates, which are particularly suited for simulating quantum fields. Practical applications and demonstrations will be carried out using quantum simulators such as Qiskit, for digital qubit-based models, and Strawberry Fields, which specializes in continuous-variable quantum information processing. Overall, this course will blend theoretical insights with practical skills, equipping students with a modern understanding of how noisy intermediate scale or futuristic quantum computers can be harnessed to explore quantum field theories.

Aninda Sinha

Pre-requistes :
Quantum mechanics 1 and 2 (PH203, PH204); Quantum Field Theory 1 is desirable.

References : 1.Quantum Computation and Quantum Information-- Nielsen and Chuang, Cambridge University Press, 2010
2. Quantum field theory and the Standard model---Matthew Schwartz, Cambridge University Press, 2014
3. IBM QISKIT https://www.ibm.com/quantum/qiskit

Instrumentation and Applied Physics

Preface

IN 201 (AUG) 3 : 0

Analytical Instrumentation

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

Manukumara Manjappa

Pre-requistes : None

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

IN 221 (AUG) 3 : 0

Sensors and Transducers

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

Atanu Kumar Mohanty , Jayanth G R , Baladitya Suri

Pre-requistes : None

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

IN 227 (AUG) 3 : 0

Control Systems Design

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

Jayanth G R

Pre-requistes : None

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

IN 232 (AUG) 3 : 0

Concepts in solid state physics

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

Chandni U , Tapajyoti Das Gupta

Pre-requistes : None

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

IN 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 *Jacob Millman and Christos C. Halkias, Integrated Electronics, McGraw-Hill International Student Edition,1972 *Robert W. Erickson and Dragan Maksimovic, Fundamentals of Power Electronics, Springer, 2001 *R.S. Kaler, Microprocessors and Microcontrollers, I. K. International Publishing

IN 205 (AUG) 0 : 3

Optical Instrumentation lab 1

1. Ray Optics: Basic Ray Optics Setup, Telescope Configuration (Beam Expansion/Collimation), Measuring Intensity Profile, Data Analysis
2. Spectroscopy: Beer-Lambert Law, Design of Absorption Spectrophotometer, Fluorescence Spectrophotometer, Role Played by Scattering, Baseline Correction, Multi-point Normalisation, Sample preparation, Spectrophotometer Characterization, Calibration, Operation, Data acquisition, Analysis, and Interpretation. Students would gain hands-on experience in the design and construction of Optical Absorption Spectrophotometer and its characterization. Experimental means of measuring the spectral resolution, Sensitivity, Accuracy, and Precision. Exposes them to different means of acquiring spectral data, analysis algorithms and interpretation of spectral features, and relating them to the properties of the analyzed material.
3. Interferometry: Michelson Interferometer, To measure the wavelength of a monochromatic light source (e.g., laser), To determine the coherence length of the light source, To analyze how path difference affects interference patterns, To interpret fringe visibility and its relation to coherence.

4. Design and Simulation: Using Ansys Zeemax design of various interferometer, ray optics experiments

Sai Siva Gorthi , Jaya Prakash , Tapajyoti Das Gupta

Pre-requistes : None

References : 1.Optics by Ajoy Ghatak, Mc Graw Hill, Higher education 2010
2. Basics of Interferometry (Second Edition) by P. Hariharan, Academic Press, 2007
3. Optics, Eugene Hecht, Pearson; 5th edition 2016

IN 204 (AUG) 0 : 3

Basic Instrumentation Laboratory

Analogue and Digital Electronics: Experiments on operational amplifiers, active filters, oscillators, A/D and D/A converters, phase-locked loops, mixers, lock-in amplifiers, switched mode power supplies, speed control of motors using PWM. Experiments on Control Systems, Sensors and Transducers.

Atanu Kumar Mohanty , Baladitya Suri

Pre-requistes : None

References : * Paul Horowitz and Winfield Hill, The Art of Electronics, Cambridge University Press, 2015

Mathematics

Preface

MA 223 (AUG) 3 : 0

Functional Analysis

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

Swarnendu Sil

Pre-requistes : None

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

MA 231 (AUG) 3 : 1

Topology

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

Siddhartha Gadgil

Pre-requistes : None

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

MA 242 (AUG) 3 : 0

Partial Differential Equations

Arka Mallick

Pre-requistes : None

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

MA 312 (AUG) 3 : 0

Commutative Algebra

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

Bharathwaj Palvannan

Pre-requistes : None

References : None

MA 333 (AUG) 3 : 0

Riemannian Geometry

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

Ved V Datar

Pre-requistes : None

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

MA 339 (AUG) 3 : 0

Geometric Analysis

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

Vamsi Pritham Pingali

Pre-requistes : None

References : Do Carmo, Riemannian Geometry.~Griffiths and Harris, Principles of Algebraic Geometry.~S. Donaldson, Lecture Notes for TCC Course "Geometric Analysis".~J.Kazdan, Applications of Partial Differential Equations To Problems in Geometry. ~L. Nicolaescu, Lectures on the Geometry of Manifolds.~T. Aubin, Some nonlinear problems in geometry.~C. Evans, Partial differential equations. ~Gilbarg

MA 361 (AUG) 3 : 0

Probability theory

Discrete parameter martingales: Conditional expectation. Optional sampling theorems. Doob’s inequalities. Martingale convergence theorems. Applications.Brownian motion. Construction. Continuity properties. Markov and strong Markov property and applications. Donsker’s invariance principle. Further sample path properties.Ergodic theory (if time permits) Probability measures and random variables, pi and lambda systems, expectation,the moment generating function, the characteristic function,laws of large numbers, limit theorems, conditional contribution and expectation, martingales, infinitely divisible laws and stable laws.

Srikanth Krishnan Iyer

Pre-requistes : None

References : Rick Durrett, Probability:theory and examples., Cambridge University Press,2010~David Williams, Probability with Martingales, Cambridge Univ., Press,1991~Peter Mörters and Yuval Peres, Brownian motion, Cambridge University Press, 2010~Olav Kallenberg, Foundations of modern Probability. Second Edition, Springer-Verlag, 2002~John Walsh, Knowing the Odds: An Introduction to

MA 212 (AUG) 3 : 0

Algebra I

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

Shaunak Vilas Deo

Pre-requistes : None

References : Artin M. Algebra. Prentice-Hall of India. 1994.~Dummit. D. S. and Foote R. M.cAbstract Algebra. McGraw-Hill. 1986.~Herstein I. N. Topics in Algebra. JohncWiley and Sons. 1995.~Lang S. Algebra. (3rd Ed.) Springer. 2002.

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

Sudhir Kumar Vempati , Jyothsna Rani Komaragiri

Pre-requistes : None

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

PH 201 (AUG) 3 : 0

Classical Mechanics

Newton’s laws, generalized co-ordinates. Lagrange’s principle of least action and equations. Conservation laws and symmetry. Integrable problems, elastic collisions and scattering. Small oscillations including systems with many degrees of freedom, rigid body motion. Hamilton’s equations. Poisson brackets. Hamilton Jacobi theory. Canonical perturbation theory, chaos, elements of special relativity. Lorentz transformations, relativistic mechanics.

Baladitya Suri

Pre-requistes : None

References :

PH 203 (AUG) 3 : 0

Quantum Mechanics-I

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

Banibrata Mukhopadhyay

Pre-requistes : None

References : None

PH 205 (AUG) 3 : 0

Math Methods of Physics

Justin Raj David

Pre-requistes : None

References : Linear vector spaces, linear operators and matrices, systems of linear equations. Eigen values and eigen vectors, classical orthogonal polynomials. Linear ordinary differential equations, exact and series methods of solution, special functions. Linear partial differential equations of physics, separation of variables method of solution. Complex variable theory; analytic functions. Taylor and Laurent

PH 211 (AUG) 0 : 3

General Physics Laboratory

Diffraction of light by high frequency sound waves, Michelson interferometer, Hall effect, band gap of semiconductors, diode as a temperature sensor, thermal conductivity of a gas using Pirani gauge, normal modes of vibration in a box, Newton’s laws of cooling, dielectric constant measurements of triglycine selenate, random walk in porous medium.

Srimanta Middey , Tapajyoti Das Gupta

Pre-requistes : None

References : None

PH 213 (AUG) 0 : 5

Advanced Experiments in Condensed Matter Physics

Anil Kumar P S

Pre-requistes : None

References : None

PH 215 (AUG) 3 : 0

Nuclear and Particle Physics

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

Jyothsna Rani Komaragiri

Pre-requistes : None

References : None

PH 217 (AUG) 3 : 0

Fundamentals of Astrophysics

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

Tarun Deep Saini

Pre-requistes : None

References : None

PH 320 (AUG) 3 : 0

Condensed Matter Physics - II

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

Sumilan Banerjee

Pre-requistes : None

References : None

PH 325 (AUG) 3 : 0

Advanced Statistical Physics

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

Vijay B Shenoy

Pre-requistes : None

References : None

PH 351 (AUG) 3 : 0

Crystal Growth, Thin films and Characterization

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

Anil Kumar P S , Akshay Singh

Pre-requistes : None

References : None

PH 360 (AUG) 3 : 0

Biological Physics

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

Sumantra Sarkar

Pre-requistes : None

References : None

PH 373 (AUG) 3 : 0

Introduction to Fluid Mechanics and Plasma Physics

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

Prantika Bhowmik

Pre-requistes :
None

References : [1] Acheson: Elementary Fluid Dynamics [2] R. Blandford & K. Thorne: Application of Classical Physics [3] F. F. Chen: Introduction to Plasma Physics and Controlled Fusion [4] A. Rai Choudhuri: The Physics of Fluids and Plasmas [5] P. G. Drain & W. H. Reid: Hydrodynamic stability [6] R. Kulsrud: Plasma Physics for Astrophysics [7] Landau & Lifshitz: Fluid Mechanics

PH 372 (AUG) 3 : 0

Radiative Processess in Astrophysics

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

Prantika Bhowmik

Pre-requistes :

None

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

Instrumentation and Applied Physics_QT

Preface

QT 207 (AUG) 3 : 0

Introduction to Quantum Computation

Axiomatic quantum theory; Quantum states, observables, measurement and evolution; Qubits versus classical bits; Spin-half systems and photon polarizations; Pure and mixed states; Density matrices; Quantum correlations; Entanglement and Bell’s theorems; Turing machines and computational complexity; Reversible computation; Universal quantum logic gates and circuits; Quantum algorithms; Database search; Fast Fourier Transform and prime factorisation.

Chandrashekar C M

Pre-requistes : None

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

QT 209 (AUG) 3 : 0

Introduction to Quantum Communications and Cryptography

Digital communication; Communication channels; Information and entropy; Shannon’s theorems; Quantum communication, dense coding and teleportation; von Neumann entropy and quantum channel capacity; General quantum evolution and superoperators; Errors and error correction codes; Stabilizer formalism; Cryptography and one-time pad; Public and private key cryptography; Quantum key distribution; Quantum cryptography. Geometrical and wave optics; Quantisation of the electromagnetic field; Photon number states; Coherent states; Squeezing and beam-splitters.

Sanjit Chatterjee , Varun Raghunathan , Manukumara Manjappa

Pre-requistes : None

References : Nielsen M.A. and Chuang I.L., Quantum Computation and Quantum Information, Cambridge University Press, 2000. Preskill J., Lecture No tes for the Course on Quantum Computation, http://www.theory.caltech.edu/people/preskill/ph229

QT 211 (AUG) 1 : 2

Basic Quantum Technology Laboratory

Intro to RF equipment – VNA, signal generators, AWGs,Oscilloscopes, Basics of Microwave Engineering – Impedance,S-parameters, Charac terisation of passive RF components – Cables, terminations,attenuators, directional couplers, RF mixer, filters, circulators and isolators, Python packages from Quantum Optics and Quantum computation – QISKIT and QuTiP, Simulating basic quantum Hamiltonians,Dissipative systems, Quantum circuit simulations.

Vibhor Singh

Pre-requistes : None

References : 1. David Pozar, Microwave Engineering 2. QISKIT and QuTiP programming manual

Mathematical Science_Int PhD

Preface

IISc's Knowledge and E-Learning Network

Preface

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

DS 265o (AUG) 3 : 1

Deep Learning for Visual Analytics

Basics of machine learning and computer vision, CNN basics, Loss function and back propagation, Object Recognition, Detection and Segmentation. Recurrent Neural Networks, LSTM, Generative Adversarial Networks (GANs), Self-supervised learning, Transformers, Explainable AI, Adversarial Robustness of Deep models.

Venkatesh Babu R

Pre-requistes :

Basics knowledge of Machine learning and Image processing.

References : 1. Dive into Deep learning, Aston Zhang, Zachary C. Lipton, Mu Li, and Alexander J. Smola (Online) 2. Recent Research papers.

AI 299o (AUG) 0 : 27

MTech Dissertation Project

Chandramani Kishore Singh

Pre-requistes : None

References : None

E1 316o (AUG) 2 : 1

Deep Learning for Robotics

Shishir Nadubettu Yadukumar

Pre-requistes : None

References : None

Data Science & Business Analytics Stream

Preface

DA 231o (AUG) 3 : 1

Data Engineering at Scale

Yogesh L Simmhan

Pre-requistes : None

References : None

DA 226o (AUG) 3 : 1

Financial Analytics

Shashi Jain

Pre-requistes : None

References : None

DA 227o (AUG) 3 : 1

Data Mining

Parthasarathy Ramachandran

Pre-requistes : None

References : None

DA 299o (AUG) 0 : 32

DSBA Stream Project

Deepak Narayanan Subramani

Pre-requistes : None

References : None

DA 204o (AUG) 3 : 1

Data Science in Practice

Pandarasamy Arjunan

Pre-requistes : None

References : None

DA 245o (AUG) 3 : 1

Linear Optimization and Network Science

Tarun Rambha

Pre-requistes : None

References : None

Electronics & Communication Engg. Stream

Preface

E1 220o (AUG) 3 : 1

Linear Algebra

Sundeep Prabhakar Chepuri

Pre-requistes : None

References : None