Preface

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

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

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

The listing of each course consists of the course number, the title, the number of credits and the semester. The course number indicates both the department and the level of the course. For instance, MA 205 indicates that the course is offered by the Mathematics department and is at the 200 level. Such 200 level courses are either basic or second level graduate courses. The 300 level courses are advanced courses primarily meant for research scholars, but can also be taken by course students who have the appropriate background; these courses can be taken only with the consent of the instructors. Most courses are offered only once a year, either in the August or in the January semester. Very few selected courses are offered in the summer term.

The number of credits is given in the form M:N, where M indicates the number of lecture credits and N the number of laboratory credits. Each lecture credit corresponds to one lecture hour per week, while each laboratory credit corresponds to a 3-hour laboratory class. Thus, a course with 2:1 credits indicates that it has 2 lecture hours and one 3-hour laboratory session each week, while a course with 3:0 credits indicates a course with 3 lecture hours and no laboratory session.

The Institute offers research-based doctoral programmes and Master's programmes that are both course-based and research-based. Each course- based Master's programme consists of core courses, electives and a dissertation project. Details of the requirements can be found under the course listing of the departments or divisions that offer them. Student are assigned faculty advisors who will advise them in selecting and dropping courses, and monitor progress through the academic program. In order to register for a course, each student needs the approval of both the faculty advisor and the course instructor. The number and type of courses taken in the first and subsequent semesters depend on the programme and department the student is registered in – the faculty advisor and the Department Curriculum Committee (DCC) will guide the students on the core and elective courses they should register for. Students are permitted to claim an exemption from core courses on the basis of having taken them earlier. Details of how to claim such an exemption are given in the Student Information Handbook.

The Institute follows a grading system, with continuous assessment. The course instructor first aggregates the individual marks of each student from the class tests, assignments and final examination scores. These marks are then mapped to letter grades, and only the grade is announced. The point values of grades are as follows: A +:10, A: 9, B+: 8, B: 7, C:6, D:5, F: 0. The grades A+ through D are passing grades, and F is a failing grade.

All the course-based programmes have a specified set of core courses. The doctoral and research-based Master's programmes may have specific core courses, which depend on the division and department. Students

in research programmes have to take a minimum number of credits as part of their Research Training Program (RTP). For PhD students in Science, the RTP consists of a minimum of 12 credits. For PhD students in Engineering who join with a Master's degree, the RTP requirement is a minimum of 12 credits. For PhD students in Engineering who join with a Bachelor's degree the RTP consists of a minimum of 24 credits. Similar RTP requirements apply for students who upgrade or continue their registration from the Masters programmes of the Institute. For the research-based Master's degree, the RTP consists of minimum 12 credits. The Integrated PhD programme has 64 credits. Research students have the option of crediting courses beyond the RTP requirement as detailed in the Student Information Handbook.

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

1st August 2023

Chair, Senate Curriculum Committee

IISc's Knowledge and E-Learning Network

Preface

IISc's Knowledge and E-Learning Network

M.Tech.(Online) Sponsored Degree Program

Preface

E9 241o (AUG) 3 : 1

Digital Image Processing

Chandra Sekhar Seelamantula

Pre-requistes : None

References : None

E1 285o (AUG) 3 : 1

Advanced Deep Representation Learning

Recap on Fundamentals of Deep Learning: Empirical Risk Minimization, Divergence minimizations and Likelihood maximization Techniques, Deep Learning Architectures (Convolutional and Recurrent Architectures).

Deep Generative Models: Introduction to Generative models, Autoregressive and invertible models, Latent variable models, Variational inference and recognition networks (VAE, WAE), Adversarial Learning, Generative Adversarial networks and variants (BiGAN, CycleGAN, StyleGAN, WGAN), Normalizing Flows, Score/Diffusion based models

Transfer Learning and Domain Adaptation: Discrepancy-Based Approaches: statistical (MMD) geometrical and architectural criteria, Generative Domain Adaptation: Adversarial and Non-adversarial Methods, Reconstruction based methods, Domain Generalization: Representation, data manipulation and Learning strategy methods

Few-shot and Meta Learning: Introduction to Multi-task and Transfer learning, Meta-learning framework for few-shot learning, Metric learning, comparators and relational networks, Optimization-based meta learning, Generative meta learning

Semi and Self-supervised Learning: Consistency Regularization, Proxy-label Methods, Active Learning, Weakly supervised learning methods, Self-supervised and Contrastive Representation Learning, Contrastive losses, Memory-bank techniques, BYOL, SWAV, SimCLR, MoCo, Hard negative mining.

Applications: Brief Discussions on Applications of each of the aforementioned topics

Prathosh A.P

Pre-requistes :
Pre-requisites: 1.

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

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 :

None

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

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 219o (AUG) 3 : 1

Quantum Computing Methods: Theory and Applications

Phani Sudheer Motamarri

Pre-requistes : None

References : None

DA 204o (AUG) 3 : 1

Data Science in Practice

Deepak Narayanan Subramani

Pre-requistes : None

References : None

E2 202o (AUG) 3 : 1

Random Process

Aditya Gopalan

Pre-requistes : None

References : None

E8 242o (AUG) 3 : 1

Radio Frequency Integrated Circuits and Systems

Vinoy K J

Pre-requistes : None

References : None

E1 220o (AUG) 3 : 1

Linear Algebra

Sundeep Prabhakar Chepuri

Pre-requistes : None

References : None

Artificial Intelligence Stream

Preface

E9 241o (AUG) 3 : 1

Digital Image Processing

Chandra Sekhar Seelamantula

Pre-requistes : None

References : None

E1 285o (AUG) 3 : 1

Advanced Deep Representation Learning

Recap on Fundamentals of Deep Learning: Empirical Risk Minimization, Divergence minimizations and Likelihood maximization Techniques, Deep Learning Architectures (Convolutional and Recurrent Architectures).

Deep Generative Models: Introduction to Generative models, Autoregressive and invertible models, Latent variable models, Variational inference and recognition networks (VAE, WAE), Adversarial Learning, Generative Adversarial networks and variants (BiGAN, CycleGAN, StyleGAN, WGAN), Normalizing Flows, Score/Diffusion based models

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Shalabh Bhatnagar

Pre-requistes :

None

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

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 219o (AUG) 3 : 1

Quantum Computing Methods: Theory and Applications

Phani Sudheer Motamarri

Pre-requistes : None

References : None

DA 204o (AUG) 3 : 1

Data Science in Practice

Deepak Narayanan Subramani

Pre-requistes : None

References : None

Electronics & Communication Engg. Stream

Preface

E2 202o (AUG) 3 : 1

Random Process

Aditya Gopalan

Pre-requistes : None

References : None

E8 242o (AUG) 3 : 1

Radio Frequency Integrated Circuits and Systems

Vinoy K J

Pre-requistes : None

References : None

E1 220o (AUG) 3 : 1

Linear Algebra

Sundeep Prabhakar Chepuri

Pre-requistes : None

References : None

Division of Biological Sciences

Preface

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

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

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

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

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

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

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

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

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

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

Prof. Usha Vijayaraghavan

Dean,

Division of Biological Sciences

DB 202 (AUG) 2 : 0

General Biology

Biology and the natural sciences; Growth of biological thought; Matter and life; Origin of life; History of life on earth; Bacteria and Protists; Fungi and other primitive plants; Seed bearing plants; Animals without back-bones; Insects, Vertebrates, Phylogeny and Systematics;Mechanisms of Evolution; Chemical basis of life; Cellular basis of life;Selected topics in plant and animal physiology; Selected topics in plant and animal ecology; Introduction To Neurophysiology with Topics In General Physiology; Behavioral ecology and sociobiology; Biological diversity on earth; Complexity; Molecular versus Organismal approaches to solving problems in Science.

Renee M Borges

Pre-requisites : None

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

DB 225 (AUG) 0 : 6

Project - II

Aravind Penmatsa

Pre-requisites : None

References : None

DB 201 (AUG) 2 : 0

Mathematics and Statistics for Biologists

Calculus: functions, limits and continuity, differentiation, integration,transcendental functions. Linear Algebra: vectors, matrices, determinants,linear equations. Statistics: elements of probability theory, discrete and continuous distributions, measures of central tendency, variability,confidence intervals, formulation of statistical hypotheses, tests of significance.

Sekar K

Pre-requisites : None

References : None

DB 250 (AUG) 2 : 0

Research Applications of Flow Cytometry

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

William Rasican Surin

Pre-requisites : None

References : Practical Flow Cytometry, Howard M Shapiro

Biochemistry

Preface

BC 201 (AUG) 2 : 0

Cell Biology

Dipankar Nandi , Patrick D Silva

Pre-requistes : None

References :

BC 202 (AUG) 2 : 0

Proteins: Structure and Function

Purification and characterization of enzymes/proteins. Determination of primary/secondary/tertiary/quaternary structures.conformational properties of polypeptide chains; Mechanism of Protein folding;. Enzyme catalysis – steady state kinetics, allosteric enzymes, kinetics of interactions of ligands,protein engineering,enzyme mechanisms.

Nagasuma R Chandra , Mahipal Ganji

Pre-requistes : None

References : None

BC 203 (AUG) 3 : 0

General Biochemistry

Biochemistry of carbohydrates and lipids. Cell membrane: structure and function. Metabolism: basic concepts and design, glycolysis and citric acid cycle, oxidative phosphorylation, bioenergetics, fatty-acid metabolism,integration and regulation of metabolism,pentose phosphate pathways and gluconeogenesis. Photosynthesis.Protein translation and regulation, cellular protein transport and protein turnover, biosynthesis and catabolism of amino acids and nucleotides, signal transduction. DNA structure, replication and repair. Transcription, regulation of gene expression in prokaryotes and eukaryotes. Recombinant DNA technology.

Patrick D Silva , Debabrata Laha

Pre-requistes : None

References : None

BC 306 (AUG) 3 : 0

Essentials in Immunology

Adaptive and innate immunity, inflammation, antibody structure and function,the complement system, antigen - antibody interaction,cells and organs of the immune system, B cell activation,immunoglobulin genes, molecular basis of antibody diversity, T cell receptors, T cell activation, major histocompatibility complex, antigen processing and presentation, lymphokines, transcription factors, hypersensitivity, autoimmunity, immunological techniques. Immunological disorders and therapy.

Dipankar Nandi , Sandeep M Eswarappa , Kesavardana Sannula

Pre-requistes : None

References : None

BC 303 (AUG) 2 : 0

Single-Molecule Approaches in Biology

This course is designed to provide a holistic picture of microscopy, starting from traditional diffraction-limited imaging to advanced super-resolution imaging and single-molecule approaches and their applications in biology. The course will begin by introducing the basics of light microscopy and the limitations of traditional imaging techniques. We will explore the historical aspects of photon detectors, which are at the heart of microscopy. Various microscopy techniques will be introduced, including confocal two-photon, 4Pi, Total Internal Reflection Fluorescence, and Fluorescence Lifetime Imaging.

We will cover both ensemble-averaging super-resolution techniques such as STED and SIM, as well as Single Molecule Localization Microscopy-based techniques like PALM, STORM, and PAINT. Additionally, the course will delve into the historical background of single-molecule imaging approaches and their evolution, while discussing the advantages and limitations of these methodologies. We will explore how these techniques can be utilized to measure individual enzyme kinetics, nucleic acid structure and dynamics, and protein-DNA interactions. Furthermore, we will examine how these techniques can be applied to investigate a wide range of biological phenomena, such as protein folding and chromatin structure.

Deepak Kumaran Nair , Mahipal Ganji

Pre-requistes : None

References : 1) Microscopy Biophysics of DNA-Protein Interactions: From Single Molecules to Biological Systems by Mark C. Williams and L. James Maher III
2) Handbook of Single Molecule Biophysics by Peter Hinterdorfer and Antoine van Oijen

Ecological Sciences

Preface

EC 301 (AUG) 2 : 1

Animal Behaviour : Mechanisms and Evolution

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

Rohini Balakrishnan , Kavita Isvaran

Pre-requistes : None

References :

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

EC 302 (AUG) 2 : 1

Plant-Animal Interactions (Ecology, Behaviour and Evolution)

The sensory biology of the interaction between plants, their animal mutualists and parasites: vision, chemoreception, olfaction and multimodal signalling;energetics of plant–animal interactions;nectar, floral and vegetative scentsand pollen chemistry; stable isotopes in the study of plant–animalinteractions; mate choice in plants; evolution of floral and fruit traits; phenotypic plasticity and inducible defenses in plants; behavioural and physiological processes in generalist and specialist herbivores, pollinators and seed dispersers; co-evolutionary dynamics of symbiosis, mutualisms and arms races

Renee M Borges

Pre-requistes : None

References : None

EC 305 (AUG) 2 : 1

Quantitative Ecology : Research Design and Inference

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

Kartik Shanker , Umesh Srinivasan

Pre-requistes : None

References :
Hilborn,R. and Mangel,M., The Ecological Detective: Confronting Models with Data. Princeton University Press, Princeton~Zuur A, Ieno EN and GM

EC 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 : 0

Ecology: Pattern and Process

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

Kartik Shanker , 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 , SRIPATI PANDITARADHYULA 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

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

Pre-requistes : None

References : None

NS 212 (JAN) 2 : 1

Neural Signal Processing

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

Supratim Ray

Pre-requistes : None

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

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 , Samay Ravindra Pande

Pre-requistes : None

References :

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

MC 206 (AUG) 2 : 0

RNA Biology

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

Saumitra Das , Purusharth Rajyaguru , Shovamayee Maharana

Pre-requistes :

References :

David G. Russell and Siamon Gordon,Phagocyte-Pathogen
"Flint SJ, Enquist L, Racaniello V, Rall GF, Skalka AM. Principles of Virology. 4th ed. ASM Press; 2015. ISBN-10: 1555819338 Knipe DM,Howley

MC 207 (AUG) 3 : 0

Molecular Biology

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

Umesh Varshney , Shovamayee Maharana

Pre-requistes : None

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

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 , Naresh Loudya

Pre-requistes : None

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

MC 213 (AUG) 2 : 0

Laboratory Rotations

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

Amit Singh

Pre-requistes : None

References : None

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.~

DB 201 (AUG) 0 : 2

Mathematics & Statistics for Biologists

Sekar K

Pre-requistes : None

References : None

DB 201 (AUG) 2 : 0

Mathematics & 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 ofsignificance.

Supratim Ray , Shantanu P Shukla

Pre-requistes : None

References : None

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.

Raghavan Varadarajan

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 , Ashok Sekhar

Pre-requistes : None

References : None

MB 205 (AUG) 2 : 0

Introduction to X-ray Crystallography

Crystal symmetry. Symmetry elements and symmetry operations,point groups,lattice space groups. Production and properties of X-rays, diffraction of X- rays by crystals, Laue equations, Bragg's Law, Fourier transformation and structure factor, reciprocal lattice, experimental techniques, rotating crystals and moving film methods. Basic ideas of structure determination, Patterson and Fourier methods,powder diffraction.

Aravind Penmatsa

Pre-requistes : None

References :
Crystal symmetry. Symmetry elements and symmetry operations,point groups,lattice space groups. Production and properties of X-rays,

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 , Vidya Mangala Prasad

Pre-requistes : None

References : None

MB 208 (JAN) 3 : 1

Theoretical and Computational Neuroscience

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

Rishikesh Narayanan , SRIPATI PANDITARADHYULA Arun

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 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

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).

Developmental Biology and Genetics

Preface

RD 201 (AUG) 2 : 0

Genetics

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

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

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

Srimonta Gayen

Pre-requistes : None

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

RD 204 (AUG) 2 : 0

Principles of Signal Transduction in Biological Systems

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

Deepak Kumar Saini

Pre-requistes : None

References : None

RD 212 (AUG) 0 : 1

Research Methods in experimental Biology

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

Varsha Singh

Pre-requistes :

Admission into the PhD program in MRDG

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

Life Sciences

Preface

LS 102 (AUG) 1 : 0

Opportunities and Extensions in Life Sciences - Pa

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

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

Deepak Kumar Saini , Maria Thaker

Pre-requistes : None

References : will be provided

LS 209 (AUG) 0 : 2

Laboratory course in Molecular Techniques

bacterial culturing, vectors, DNA isolation, transformation, cloning, expression and purification of proteins; characterization by western blotting/ ELISA; cell culture, transfection, stable line generation, gene expression analysis by RT-PCR; fluorescence microscopy, immunofluorescence; viability assessment; Alamar blue / MTT assay; flow cytometry and cell sorting.

Biophysical techniques - Concept of absorption and spectroscopy. Concept of protein/nucleic acid folding (CD and Fluorescence); Separation of protein and identification (Chromatography and Mass spectrometry); Bioinformatics.

Annapoorni Rangarajan , Deepak Kumar Saini , Saravanan Palani

Pre-requistes : None

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

LS 204 (AUG) 3 : 0

Biochemistry and Biophysics

Biophysics - Atoms, molecules, and chemical bonds. Covalent and non-covalent interactions (vdW, H-bond, electrostatic interaction, hydrophobic interaction, p-p, cat-p interaction); Composition of biomolecules (proteins, nucleic acids, carbohydrate, lipids) and their conformational features (Proteins: Rama plot, secondary structure, domains, folds. Nucleic acids: A, B, Z DNA, t-RNA, micro RNA); Folding and stability of proteins and nucleic acids; Principles of biophysical chemistry (concept of acid-base/pH, reaction kinetics and thermodynamics); Application of Spectroscopic techniques to study biomolecular interaction (UV-Vis spectroscopy, Fluorescence spectroscopy, Fluorescence anisotropy, Infrared spectroscopy, Raman spectroscopy, Circular Dichroism spectroscopy, Surface plasmon spectroscopy, and its application to study biomolecular interaction; Methods to study Proteins - Basic techniques like mass spectrometry, X-ray crystallography, NMR, and cryo-EM.

Biochemistry - The chemical components of a cell, Structure and function of biological molecules, Protein Structure Function and Dynamics, Metabolic pathways and metabolism as integrated regulated systems, Cell membrane, cellular transport, Enzyme kinetics, complex cellular processes. Bioenergetics, glycolysis, oxidative phosphorylation, coupled reactions, biological energy transducers. Principles of catalysis, enzymes and enzyme kinetics. Metabolism of carbohydrates, lipids, amino acids nucleotides and vitamins.

Jayanta Chatterjee , Purusharth Rajyaguru

Pre-requistes : None

References : The Molecules of Life: Physical and Chemical Principles by John Kuriyan, Boyana Konforti, David Wemmer

Biochemistry by Jeremy M. Berg, Lubert Stryer, John Tymoczko, Gregory Gatto

LS 203 (AUG) 3 : 0

Microbiology, Virology and Immunology

Microbiology - Microbial taxonomy; Microbial diversity, evolution and genomics; Horizontal gene transfer, Microbes as model of development, and as bioreactors and sensors; bioremediation; structure-function of bacterial cell; Bacterial physiology and nutrition; Phages, Plasmids and Transposons; bacterial pathogenesis; Antibiotics: mode of action and mechanisms of resistance; Quorum sensing and biofilms; Host-pathogen interactions and immune surveillance; Diagnostics and vaccine development; Origin of cellular life; Host-associated and free-living microbes; Physiological heterogeneity in bacterial populations; Bacterial predation, and survival strategies.

Virology – Introduction to viruses, life cycles of temperate and lytic bacteriophages; Fundamental concepts in virology, biology and pathogenesis of major viral pathogens; Introduction to applied virology.

Immunology - Cells and organs of the Immune system, Innate Immunity & Inflammation, B cell Development, Structure-function

Dipshikha Chakravortty , Samay Ravindra Pande

Pre-requistes : None

References :

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

Division of Chemical Sciences

Preface

The Division of Chemical Sciences comprises of the Department of Inorganic and Physical Chemistry (IPC), Materials Research Centre (MRC), Department of Organic Chemistry (OC) and Solid State and Structural Chemistry Unit (SSCU). Students with a basic/advanced degree in Chemistry, Physics, Biology, or many branches of engineering are eligible for admission to the doctoral program. In addition, the division also admits B.Sc. graduates to the Integrated PhD program. Since 2011, the division is also actively engaged in the four-year Bachelor of Science (Research) program and has introduced several courses at the undergraduate level.

The courses offered by various departments carry a two-letter departmental code that is followed by a three digit number; of which, the first digit refers to the course level. In addition, courses offered to the Integrated PhD students are listed separately with another code. The courses offered by the different departments have been grouped as follows:

CD Integrated Ph D

IP Inorganic and Physical Chemistry

MR Materials Research Centre

OC Organic Chemistry

SS Solid State and Structural Chemistry

Each department/centre/unit offers courses on basic as well as specialized topics designed to provide students with a sound foundation in both theoretical and experimental aspects. There are specified requirements for completing the research training programme (RTP) for students registering under various streams at the Institute. For details concerning these requirements, students are advised to approach the Chair of the Department/Centre/Unit.

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

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

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

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

Prof. G. Mugesh

Dean

Division of Chemical Sciences

CD 213 (AUG) 3 : 0

Organic Chemistry – Structure and Reactivity

Stereochemistry and conformational analysis. Methods of deducing organic reaction mechanisms, Hammond postulate,Curtin-Hammett principle, linear freeenergy relationships; Hammett equation; kinetic isotope effects. Electronic effects in organic compounds, aromaticity,frontier orbital theory, steric effects;organic transformations and molecular rearrangements; reactive intermediates, classical and nonclassical carbocations, carbanions, free radicals, carbenes, nitrenes, arynes,radical ions, diradicals,concerted reactions,Woodward-Hoffman rules.

Mrinmoy De,Garima Jindal

Pre-requisites : None

References :

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

CD 204 (AUG) 3 : 0

Chemistry of Materials

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

Natarajan S

Pre-requisites : None

References : None

CD 211 (AUG) 3 : 0

Physical Chemistry – I Quantum Chemistry and Group Theory

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

Sujit Das

Pre-requisites : None

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

CD 214 (AUG) 3 : 0

Basic Mathematics

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

Sheetal Kumar Jain

Pre-requisites : None

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

CD 215 (AUG) 0 : 4

Organic & Inorganic Chemistry Laboratory

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

Abhishake Mondal,Susanta Hazra

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.

Mugesh G , Sandya S

Pre-requistes : None

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

IP 312 (AUG) 3 : 0

Advanced Organometallic Chemistry

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

Thilagar P

Pre-requistes : None

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

IP 330 (AUG) 3 : 0

Special Topics in Physical Chemistry

Topic: Chemistry with Quantum Light : A theoretical primer. [1] Quantum Electrodynamics (QED): Maxwell's equations, gauges, quantisation of light, coherent states. [2] Matter-radiation interaction: Dipole approximation. Atom-photon and molecule- photon interactions. Density matrix approach. [3] Cavity QED: Hamiltonian, two level systems and treatment of the Rabi model, Jaynes-Cummings, Tavis-Cummings, and Dicke models, quantum coherence and decoherence, the quantum vaccuum, introduction to Fabry-Perot cavity. [4] Molecular polaritions: What is a polariton? Vibrational strong coupling, hybrid light-matter states, chemical reactions (does transition state theory work?) and control in optical cavities. Importance of dynamics, vibrational energy flow, cavity losses, decoherence and outstanding challenges.

Sai G Ramesh

Pre-requistes :
Basic courses on quantum mechanics (CD211 or better), statistical mechanics (CD221 or better). Some knowledge of rudimentary optics
References : [1] J. J. Sakurai, Advanced Quantum Mechanics, Addison-Wesley 1967. [2] B. C. Cohen-Tannoudji, J. Dupont-Roc, G. Grynberg, Photons and Atoms: Introduction to Quantum Electrodynamics, Wiley-VCH 1997. [3] C. P. Meystre, M. Sargent, Elements of Quantum Optics, 3rd Ed, Springer 1999. [4] Recent review articles on the topic will be indicated by the instructor during the course.

Materials Research Centre

Preface

MR 309 (AUG) 3 : 0

Introduction to Supramolecular Chemistry

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

Subinoy Rana

Pre-requistes : None

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

MR 310 (AUG) 3 : 0

Light emitting materials and devices

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

Rajamalli P

Pre-requistes : None

References : 1. OLED Fundamentals (Materials, Devices, and Processing of Organic Light-Emitting Diode) by Daniel J. Gaspar and Evgueni Polika
2. Organic light- emitting diodes (OLEDs) by Alastair Buckley
3. Color Vision and Colorimetry Theory and Applications by Daniel Malacara

Organic Chemistry

Preface

OC 302 (AUG) 3 : 0

Asymmetric Catalysis: From Fundamentals to Frontiers

Basics of asymmetric catalysis including energetics of reactions;Lewis acid &cLewis base catalysis; Kinetic, Dynamic Kinetic and Parallel Kinetic Resolution; Desymmetrization reactions; Mechanistic studies of asymmetric reactions:cnonlinear effects, autocatalysis and autoinduction; Bifunctional, Dual and Multifunctional catalyst systems; Modern aspects of asymmetric catalysis:counterion-directed catalysis, cooperative, dual and merged catalysis,asymmetric photocatalysis etc.Applications of asymmetric catalysis.

Santanu Mukherjee

Pre-requistes : None

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

Solid State and Structural Chemistry

Preface

SS 201 (AUG) 3 : 0

Thermodynamics and Statistical Mechanics

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

Govardhan P Reddy

Pre-requistes : None

References : None

SS 202 (AUG) 3 : 0

Introductory Quantum Chemistry

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

Awadhesh Narayan

Pre-requistes : None

References : None

SS 205 (AUG) 3 : 0

Symmetry and Structure in the Solid State

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

Sreedhara M B

Pre-requistes : None

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

SS 209 (AUG) 3 : 0

Electrochemical Systems

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

Naga Phani B Aetukuri

Pre-requistes : None

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

SS 304 (AUG) 3 : 0

Solar Energy: Advanced Materials and Devices

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

Satish Amrutrao Patil

Pre-requistes : None

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

Chemical Science

Preface

CY 215 (AUG) 0 : 3

Advanced Laboratory - 1

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

Erode N Prabhakaran , Abhishake Mondal , Susanta Hazra

Pre-requistes : None

References :

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

Division of EECS

Preface

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

E0 Computer Science and Engineering

E1 Intelligent Systems and Automation

E2 Communication Systems

E3 Electronic Devices, Circuits and Technology

E4 Power and Energy Systems

E5 High Voltage and Insulation Engineering

E6 Power Electronics and Drives

E7 Photonic Devices, Circuits and Systems

E8 Electromagnetic, Microwaves and Antennas

E9 Signal Processing, Acoustics and Bioengineering

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

M Tech in Electrical Engineering (EE)

M Tech in Communication and Networks (ECE)

M Tech in Computer Science and Engineering (CSA)

M Tech in Electronics Systems Engineering (ESE)

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

M Tech in Signal Processing (EE and ECE)

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

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

Prof. Rajesh Sundaresan

Dean

Division of EECS

Computer Science and Automation

Preface

E0 238 (AUG) 3 : 1

Intelligent Agents

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

Pre-requistes : None

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

E0 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 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 , Chaya Ganesh

Pre-requistes : None

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.

Anand Louis , Arindam Khan

Pre-requistes : None

References : None

E0 251 (AUG) 3 : 1

Data Structures and Algorithms

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

Shirish Krishnaji Shevade , Matthew Jacob T

Pre-requistes : None

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

E0 256 (AUG) 3 : 1

Theory and Practice of Computer Systems Security

This course will seek to equip students with the fundamental principles and practice of computer systems security. The course will cover the major techniques of offense and defense, thereby educating students to think both as attackers and defenders. By the end of the course, students will have been exposed to the state of the art, and will be equipped with the background to start conducting original research in computer systems security. Core concepts such as basic security goals, threat models, notion of TCB and security policies vs. mechanisms. Operating system primitives for protection, reference monitors, authentication, and authorization. Examples of classic security policies from the literature (e.g., Biba, BLP) and their realization on modern systems. Various forms of hijacking attacks, such as buffer overflows, return-oriented programming, and non-control data attacks, and examples of such attacks as used by exploits in the wild. Design and implementation of defenses such as control-flow integrity, ASLR, privilege separation, capabilities,information-flow control and virtual machine introspection. Attacks and defenses against the Web ecosystem, mobile devices and the cloud platform.Emerging role of modern hardware in improving systems security. Other assorted topics based on current research literature. References: Security Engineering, 2nd Edition, Wiley, by Ross Anderson. http:// www.cl.cam.ac. uk/~rja14/book.html (free online copy) Research papers from systems security conferences and journals.

Vinod Ganapathy

Pre-requistes : None

References : None

E0 261 (AUG) 3 : 1

Database Management Systems

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

Jayant R Haritsa

Pre-requistes : None

References : Database Systems Concepts, H. Korth, A. Silberschatz and S.Sudarshan, McGraw-Hill~Fundamentals of Database Systems R. Elmasri and S. B. Navathe, Addison-Wesley. ~Database Management Systems R.Ramakrishnan and J. Gehrke, McGraw-Hill. ~Readings in Database Systems M. Stonebraker and J. Hellerstein, Morgan Kaufmann. ~Recent Conference and Journal papers.

E0 270 (JAN) 3 : 1

Machine Learning

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

Ambedkar Dukkipati

Pre-requistes : None

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

E0 322 (JAN) 3 : 1

Topics in Algebra and Computation

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

Chandan Saha

Pre-requistes : None

References : None

E0 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

Pre-requistes : None

References : None

E1 277 (JAN) 3 : 1

Reinforcement Learning

Introduction to reinforcement learning, introduction to stochastic dynamic programming, finite and infinite horizon models, the dynamic programming algorithm, infinite horizon discounted cost and average cost problems,numerical solution methodologies, full state representations, functionapproximation techniques, approximate dynamic programming, partially observable Markov decision processes, Q-learning, temporal difference learning, actor-critic algorithms.

Shalabh Bhatnagar , Gugan Chandrashekhar Thoppe

Pre-requistes : None

References : References: D.P.Bertsekas and J.N.Tsitsiklis,Neuro-Dynamic Programming, Athena Scientific, 1996. R.S.Sutton and A.G.Barto, Reinforcement Learning: An Introduction, MIT Press, 1998. D.P.Bertsekas,Dynamic Programming and Optimal Control, Vol.I, Athena Scientific, 2005.

E1 396 (AUG) 3 : 1

Topics in Stochastic Approximation Algorithms

Shalabh Bhatnagar

Pre-requistes : None

References : None

E0 206 (AUG) 3 : 1

Theorist's Toolkit

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

Anand Louis

Pre-requistes : None

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

CS 299 (JAN) 0 : 21

M Tech Project CSA

M Tech Project

Ambedkar Dukkipati

Pre-requistes : None

References : M Tech Project

E0 360 (AUG) 3 : 1

Hypergraphs and Set systems

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

Sunil Chandran L

Pre-requistes :

Reasonable level of previous exposure with Combinatorics/Graph

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

E0 213 (JAN) 3 : 0

Quantum Safe Cryptography

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

Sanjit Chatterjee

Pre-requistes :

Introduction to Quantum Computation (QT 207) or an equivalent
References : (1) Bernstein D.J., Buchmann J. and Dahmen E. (Eds.): Post-Quantum Cryptography, Springer, 2010. (2) Galbraith S.D., Mathematics of Public Key Cryptography, Cambridge University Press, 2012. (3) Menezes A.J., van Oorshot P.C. and Vanstone S.A., Handbook of Applied Cryptography, CRC Press, 1996. (4)Recent research papers in the relevant areas.

E0 214 (AUG) 3 : 0

Applied Linear Algebra and Optimization

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

Shirish Krishnaji Shevade

Pre-requistes : None

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

E0 294 (JAN) 3 : 1

Systems for Machine Learning

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

Sumit Kumar Mandal

Pre-requistes :

E0-243
References : Sze, Chen, Yang and Emer: “Efficient Processing of DNNs,” Morgan&Claypool Press. 2021. ISBN: 9781681738321

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

E1 384 (JAN) 3 : 0

Topics in Stochastic Optimization

Introduction to optimization methods, algorithms for optimization, Basics of Markov decision processes, stochastic approximation algorithms, stochastic gradient methods, gradient and Hessian estimation approaches, optimization via simulation, Markov chain Monte-Carlo methods, Simulated annealing, Reinforcement learning algorithms – temporal difference learning, policy gradient algorithms, actor-critic methods.

Shalabh Bhatnagar

Pre-requistes :
A first course on probability theory

References : 1. S.Asmussen and P.W.Glynn, Stochastic Simulation: Algorithms and Analysis, Springer, 2007
2. M.Hardt and B.Recht, Patterns, Predictions and Actions: Foundations of Machine Learning, Princeton University Press, 2022
3. S.Bhatnagar, H.L.Prasad, and L.A.Prashanth, Stochastic Recursive Algorithms for Optimization: Simultaneous Perturbation Methods, Springer 20

Electrical Communication Engineering

Preface

E1 245 (AUG) 3 : 0

Online Prediction and Learning

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

Aditya Gopalan

Pre-requistes : None

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

E2 201 (AUG) 3 : 0

Information Theory

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

Utpal Mukherji

Pre-requistes : None

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

E2 202 (AUG) 3 : 0

Random Processes

The axioms of probability theory, continuity of probability, independence and conditional probability. Random variables and their distribution, functions of a random variable, expectation. Jointly distributed random variables, conditional distribution and expectation, Gaussian random vectors. Convergence of sequences of random variables, Borel-Cantelli Lemma, laws of large numbers and central limit theorem for sequences of independent random variables, Markov inequality. Definition of a random process, stationarity. Correlation functions of random processes in linear systems, power spectral density. Discrete time Markov chains, recurrence analysis, Foster's theorem. The Poisson process.

Rajesh Sundaresan

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 208 (AUG) 3 : 0

Topics in Information Theory & Coding

Relevant journal articles.

Sundar Rajan B , Navin Kashyap

Pre-requistes : None

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

E2 211 (AUG) 3 : 0

Digital Communication

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

Sundar Rajan B

Pre-requistes : None

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

E2 212 (AUG) 3 : 0

Matrix Theory

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

Sundeep Prabhakar Chepuri

Pre-requistes :

Basic linear algebra, probability, and knowledge of a
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 251 (AUG) 3 : 0

Communications Systems Design

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

Chockalingam A

Pre-requistes : None

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

E3 220 (AUG) 3 : 0

Foundations of Nanoelectronic Devices

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

Kausik Majumdar

Pre-requistes : None

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

E7 211 (AUG) 2 : 1

Photonics Integrated Circuits

Principles: Introduction to Photonics; optical waveguide theory; numerical techniques and simulation tools; photonic waveguide components – couplers, tapers, bends, gratings;electro-optic, acousto-optic,magneto-optic and non- linear optic effects;modulators, switches,polarizers, filters,resonators,optoelectronics integrated circuits;amplifiers, mux/demux, transmit receive modules;Technology: materials – glass, lithium niobate, silicon, compound semiconductors, polymers;fabrication – lithography, ion-exchange,deposition,diffusion; process and device characterization; packaging and environmental issues; Applications:photonic switch matrices;planar lightwave circuits,delay line circuits for antenna arrays,circuits for smart optical sensors; optical signal processing and computing; micro-opto-electro-mechanical systems; photonic bandgap structures; VLSI photonics

Varun Raghunathan

Pre-requistes : None

References : C. R. Pollock and M. Lip Son, Integrated Photonics, Kluwer Pub., 2003.~T.Tamir, (ed), Guided-wave optoelectronics, (2nd edition), Springer- Verlag, 1990.~H. Nishihara, M. Haruna, and T.Suhara,Optical Integrated Circuits, McGraw-Hill, 1988.~E. J.Murphy, (Editor), Integrated Optical Circuits and Components: Design and Applications, Marcel and Dekker,1999.~Current literature: Special issues

E8 202 (AUG) 2 : 1

Computational Electromagnetics

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

Dipanjan Gope

Pre-requistes : None

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

E9 208 (AUG) 3 : 1

Digital Video: Perception and Algorithms

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

Rajiv Soundararajan

Pre-requistes : None

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

E8 304 (AUG) 3 : 0

Electromagnetic Metamaterials: Concepts and Applications

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

Debdeep Sarkar

Pre-requistes :

Preliminary knowledge about circuit design concepts along
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 :

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

E9 333 (AUG) 3 : 1

Advanced Deep Representation Learning

Reference Material:

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

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

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

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

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

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

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

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

Prathosh A.P

Pre-requistes :

1. A course on probability theory

References :

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

E2 217 (AUG) 3 : 1

Machine Learning for Wireless Communication

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

Sudhan Majhi

Pre-requistes :
Basics of Machine Learning and python

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

E7 222 (AUG) 3 : 0

Lasers: Principles

Review of Electromagnetic theory: Maxwell's Equations, Wave Equations for free space and Dielectric media, the uncertainty relationships, Spreading of Electromagnetic beam, Wave Propagation in Anisotropic media, Snell's laws, Brewster's angle, Coherent Electromagnetic Radiation, Examples of coherence effects.
Ray Tracing and Gaussian Beams: Matrix representation of ray tracing, Applications of Ray tracing, Stability diagram, Ray tracing through continuous lens like media, wave transformation by lens, TEM Waves, Lowest-order TEM¬0,0 Mode, Higher Order Modes, ABCD law for Gaussian beams, Divergence of Higher Order Modes: Spatial Coherence
Optical Cavities: Gaussian beams in simple stable resonators, ABCD laws to cavities, Mode volume in optical cavity, Resonance, Sharpness of resonance: Q factor and finesse, Photon lifetime, Diffraction losses, Cavity with gain
Atomic radiation: Blackbody radiation theory, Einstein theory of light matter interaction, light emission and absorption, spontaneous emission, Stimulated emission, absorption, Line shape and line broadening mechanisms.
Laser Oscillation and Amplification: Gain, feedback, and threshold for laser oscillation; Laser oscillation, amplification and Gain saturation in homogeneous and inhomogeneous broadened transitions, Multimode oscillation, Amplified Spontaneous Emission, mode selection, single-frequency lasers, laser frequency and intensity noise and reduction.
Laser characteristics: Factors in efficiency, two, three, four level lasers, CW lasers, Laser dynamics, Gain Switching, Q Switching, Mode locking.
Laser Excitation: Three and Four Level Lasers, Ruby Lasers, Rare Earth Lasers and Amplifiers, Broadband Optical Gain, Tunable Lasers, Gaseous-Discharge lasers, Excimer Lasers, Free Electron lasers
Semiconductor Lasers: Review of elementary semiconductor theory, Occupation Probability, Optical absorption and Gain in Semiconductors, Diode Laser, Quantum Size effects, Vertical Surface cavity Emitting lasers, Modulation of semiconductor lasers.
Spectroscopy of common lasers: Atomic notation, Molecular structure, Electronic states in molecules
Detection of optical radiation: Quantum detectors, Solid-state Quantum detectors, Noise considerations, Mathematics of Noise, Source of Noise, Limits of detection systems.

Supradeepa V R , Balaswamy Velpula

Pre-requistes :
NE213: Introduction to Photonics course is Preferable but not Mandatory
References : 1. Laser Electronics: Joseph T. Verdeyen (latest Edition)
2. Principles of Lasers: Orazio Svelto (latest Edition)
3. Lasers: A. E. Siegmann (latest Edition)

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.

E0 247 (AUG) 3 : 1

Sensor Networks

Basic concepts and issues, survey of applications of sensor networks, homogeneous and heterogeneous sensor networks, topology control and clustering protocols, routing and transport protocols, access control techniques,location awareness and estimation, security information assurance protocols,data fusion and management techniques, query processing, energy efficiency issues, lifetime optimization, resource management schemes, task allocation methods, clock synchronization algorithms. A Wi-Fi application, Communication between MSP 430 based Sensor nodes and with addition of Extra Sensors. Compute Total Energy and estimated life of Battery.

Rathna G N

Pre-requistes : None

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

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.

Vaibhav Katewa , 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 221 (AUG) 2 : 1

DSP and AI Techniques in Power System Protection

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

Sarasij Das

Pre-requistes : None

References :
References: Warrington A R, and Von C, Protective Relaying: Theory and Practice, Vol. II, Chapman and Hall, 1970.,IEEE Tutorial Course on

E4 231 (AUG) 3 : 0

Power System Dynamics and Control

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

Gurunath Gurrala

Pre-requistes : None

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

E4 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

E5 206 (AUG) 3 : 0

HV Power Apparatus

HV power transformers, equivalent circuit,surge phenomenon,standing and traveling wave theory, ladder network representation,short circuit forces, impulse testing,diagnostics and conditionmonitoring of transformers, natural frequencies and its measurement,moderntechniques. Introduction to HV switching devices,electric arcs, short circuit currents, TRV, CB types, air,oil and SF6 CB, short circuit testing.

Satish L , Rajanikanth B S

Pre-requistes : None

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

E5 213 (AUG) 3 : 0

EHV/UHV Power Transmission Engineering

Joy Thomas M

Pre-requistes : None

References : None

E5 215 (AUG) 2 : 1

Pulsed Power Engineering

Joy Thomas M

Pre-requistes : None

References : None

E6 201 (AUG) 3 : 1

Power Electronics

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

Narayanan G , Vishnu Mahadeva Iyer

Pre-requistes : None

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

E6 224 (AUG) 3 : 0

Topics in Power Electronics and Distributed Generation

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

Vinod John

Pre-requistes : None

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

E8 201 (AUG) 3 : 0

Electromagnetism

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

Udaya Kumar

Pre-requistes : None

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

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

E1 246 (AUG) 3 : 0

Topics in Networked and Distributed Control

Core topics:
Relevant background topics in control;

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

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

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

Pavankumar Tallapragada

Pre-requistes : None

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

E9 241 (AUG) 2 : 1

Digital Image Processing

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

Soma Biswas , Rajiv Soundararajan

Pre-requistes : None

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

E9 291 (AUG) 2 : 1

DSP System Design

DSP Architecture: Single Core and Multicore; Pipelining and Parallel Processing; DSP algorithms: Convolution, Correlation, FIR/IIR filters, FFT,adaptive filters, sampling rate converters, DCT, Decimator, Expander and Filter Banks. DSP applications. Weekly laboratory exercises using MATLAB and CCS 5.4 simulator

Rathna G N

Pre-requistes : None

References :
References: 1. Morrow, Michael G. Welch, Thad B. Wright, Cameron H. G - Real-Time Digital Signal Processing from MATLAB to C with the TMS320C6x

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.

Kunal Narayan Chaudhury

Pre-requistes :
none.

References :
[1] S. Axler, Linear Algebra Done Right, Springer, 2015.
[2] C. Meyer,

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

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

Electronic Systems Engineering

Preface

E0 284 (AUG) 2 : 1

Digital VLSI Circuits

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

Viveka Konandur Rajanna

Pre-requistes : None

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

E1 201 (AUG) 2 : 1

Hardware Acceleration and Optimization for Machine Learning

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

Chetan Singh Thakur

Pre-requistes : None

References : 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 , Joy Kuri

Pre-requistes : None

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

E2 243 (AUG) 2 : 1

Mathematics for Electrical Engineers

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

Joy Kuri , Chandramani Kishore Singh

Pre-requistes : None

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

E3 235 (AUG) 2 : 1

Design for Analog Circuits

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

Naga Krishna V.

Pre-requistes : None

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

E3 245 (AUG) 2 : 1

Processor System Design

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

Kuruvilla Verghese

Pre-requistes : None

References : Computer Organization and Design: The Hardware/Software Interface, The Morgan Kaufmann, By David A. Patterson and John L. Hennessy~Computer Architecture: A Quantitative Approach, The Morgan Kaufmann By John L. Hennessy and David A.Patterson~Modern Processor Design: Fundamentals of Superscalar Processors,McGraw-Hill By John P. Shen ~Current Literature

E3 258 (AUG) 2 : 1

Design for Internet of Things

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

Prabhakar T V

Pre-requistes : None

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

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.

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

Biosystems Science and Engineering

Preface

BE 203 (AUG) 0 : 1

Bioengineering Practicum 1

Medhavi Vishwakarma , Ajay Sanjay Tijore

Pre-requistes : None

References : None

BE 204 (AUG) 0 : 1

Bioengineering Practicum 2

Medhavi Vishwakarma , Ajay Sanjay Tijore

Pre-requistes : None

References : None

BE 206 (AUG) 3 : 0

Biology for Engineers

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

Rachit Agarwal , Ajay Sanjay Tijore

Pre-requistes : None

References :
Biology: Concepts and Connections, Third Edition. Campbell, Mitchell and Reece.~Molecular Biology of the Cell, Fourth Edition. B. Alberts,

BE 207 (AUG) 3 : 0

Mathematical Methods for Bioengineers

Narendra M Dixit , Mohit Kumar Jolly

Pre-requistes : None

References : None

BE 210 (AUG) 3 : 0

Drug Delivery: Principles and Applications

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

Rachit Agarwal

Pre-requistes : None

References :
Biology: Concepts and Connections, Third Edition. Campbell, Mitchell and Reece.~Molecular Biology of the Cell, Fourth Edition. B. Alberts,

BE 213 (AUG) 2 : 0

Fundamentals of Bioengineering 1

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

Bhushan J Toley , Mohit Kumar Jolly

Pre-requistes : None

References : None

BE 219 (AUG) 2 : 0

Essentials of Research and Innovation

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

Siddharth Jhunjhunwala , Sanhita Sinharay

Pre-requistes :

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

Nanoscience and Engineering

Preface

NE 200 (AUG) 2 : 0

Technical Writing and Presentation

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

Supradeepa V R

Pre-requistes : None

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

NE 202 (AUG) 0 : 2

Micro AND Nano Fabrication

This course is designed to give training in device processing at the cleanroom facility. Four specific modules will be covered to realize four different devices i) p-n junction diode, ii) MOS capacitor iii) MEMS Cantilever iv)Microfluidic channel.

Shankar Kumar Selvaraja , Sushobhan Avasthi

Pre-requistes : None

References : None

NE 203 (AUG) 3 : 0

Advanced micro and nanofabrication technology and process

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

Shankar Kumar Selvaraja , Sushobhan Avasthi

Pre-requistes : None

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

NE 213 (AUG) 3 : 0

Introduction to Photonics

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

Ambarish Ghosh , Shankar Kumar Selvaraja

Pre-requistes : None

References : None

NE 215 (AUG) 3 : 0

Applied Solid State Physics

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

Akshay K Naik

Pre-requistes : None

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

NE 222 (AUG) 3 : 0

MEMS: Modeling, Design, and Implementation

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

Saurabh Arun Chandorkar , Gayathri Pillai

Pre-requistes : None

References : 1.Stephen D. Senturia, “Microsystem Design”, Kluwer Academic Publishers, 2ndPublishing, 2001. 2.G. K. Ananthasuresh, K. J. Vinoy, S. Gopalakrishnan, K. N. Bhat and V.K. Aatre, “Micro and Smart Systems”, Wiley India, 2010.

NE 231 (AUG) 3 : 0

Microfluidics

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

Prosenjit Sen

Pre-requistes : None

References : Brian J. Kirby, Micro- and Nanoscale Fluid Mechanics, Cambridge University Press,P.-G. de Gennes, F. Brochard-Wyart, and D. Quere, Capillarity and Wetting Phenomena, Springer,R. F. Probstein, Physicochemical Hydrodynamics,Wiley Inter-Science,-,-

NE 250 (AUG) 1 : 0

Entrepreneurship, Ethics and Societal Impact

This course is intended to give an exposure to issues involved in translating the technologies from lab to the field. Various steps and issues involved in productization and business development will be clarified, drawing from experiences of successful entrepreneurs in high technology areas. The intricate relationship between technology, society and ethics will also be addressed with illustrations from people involved in working with the grass root levels of the society.

Navakanta Bhat

Pre-requistes : None

References : None

NE 203 (AUG) 3 : 0

Advanced micro- and nanofabrication technology and process

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

Shankar Kumar Selvaraja

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 316 (AUG) 3 : 0

Advanced Electron Microscopy in Materials Characterization

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

Pavan Nukala

Pre-requistes :
MR306 Electron Microscopy in Materials Characterization

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

NE 206 (AUG) 3 : 0

Semiconductor Device Physics: Basic Devices

Energy bands in solids; Reciprocal space; Brillouin Zone (BZ); Fermi Dirac distribution; Doping; Density of states; Low-field transport; High-field transport; Carrier flow by Diffusion and Drift; Excess carriers and recombination processes; PN junction at thermal equilibrium; PN junction under bias; Transient behavior of p-n junction; Solar cell and photodetector; Metal-semiconductor (Schottky and Ohmic junctions; Current transport mechanisms; Introduction to compound semiconductors; BJT; MOS capacitor; MOSFET; Short channel effects

Sushobhan Avasthi

Pre-requistes : None

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

NE 281 (AUG) 3 : 0

Statistical and probabilistic data analysis techniques

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

Manoj Varma

Pre-requistes : None

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

NE 240 (AUG) 3 : 0

Materials design principles for electronic, electromechanical and optical funct

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

Pavan Nukala

Pre-requistes : None

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

NE 352 (AUG) 3 : 0

Quantum transport in low dimensional materials

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

Chandan Kumar

Pre-requistes :
Exposure to solid state Physics course

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

NE 201A (AUG) 3 : 0

Theory of structural and functional characterization

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

Akshay K Naik , Gayathri Pillai

Pre-requistes : None

References : Lecture notes

Computational and Data Sciences

Preface

DS 200 (AUG) 0 : 1

Research Methods

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

Debnath Pal

Pre-requistes : None

References : None

DS 201 (AUG) 2 : 0

Bioinformatics

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

Sekar K , 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,

DS 211 (AUG) 3 : 0

Numerical Optimization

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

Deepak Narayanan Subramani

Pre-requistes : None

References : None

DS 221 (AUG) 3 : 1

Introduction to Scalable Systems

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

Sathish S Vadhiyar , Yogesh L Simmhan

Pre-requistes : None

References : None

DS 284 (AUG) 2 : 1

Numerical Linear Algebra

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

Phani Sudheer Motamarri

Pre-requistes : None

References : None

DS 288 (AUG) 3 : 0

Numerical Methods

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

Ratikanta Behera

Pre-requistes : None

References : None

DS 290 (AUG) 3 : 0

Modelling and Simulation

Soumyendu Raha

Pre-requistes : None

References : P.E Kloeden, Platen, E., Numerical Solution of Stochastic Differential Equations . Springer, Berlin. doi : 10.1007/978 - 3 - 662 - 12616 - 5 . ISBN 978 - 3 - 540 - 54062 - 5 ,1992~Banks, J., Carson, J. S., Nelson, B. L., & Nicol, D. M. (2013). Discrete-event system simulation: Pearson new international edition. Pearson Higher Ed.~Asmussen, S., & Glynn, P. W. (2007). Stochastic simulation: algorithms

DS 215 (AUG) 3 : 0

Introduction to Data Science

Course Description:

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

Detailed Syllabus:

- Probability and Statistics Primer: Fun

Anirban Chakraborty

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

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

DS 261 (AUG) 3 : 1

Artificial Intelligence for Medical Image Analysis

X-ray Physics, interaction of radiation with matter, X-ray production, X-ray tubes, dose, exposure, screen-film radiography, digital radiography, X-ray mammography, X-ray Computed Tomography (CT). Basic principles of CT, single and multi-slice CT. Tomographic image reconstruction, filtering, image quality, contrast resolution, CT artifacts. Magnetic Resonance Imaging (MRI): brief history, MRI major components. Nuclear Magnetic Resonance: basics,localization of MR signal, gradient selection, encoding of MR signal, T1 and T2 relaxation, k-space filling, MR artifacts. Ultrasound basics, interaction of ultrasound with matter, generation and detection of ultrasound, resolution. Doppler ultrasound, nuclear medicine(PET/SPECT), multi-modal imaging, PET/CT,SPECT/CT, oncological imaging, medical image processing and analysis, image fusion, contouring, segmentation, and registration.
Learning outcomes:
On successful completion of the course, the student should be able to:
Identify the basic c

Vaanathi Sundaresan

Pre-requistes :
Basic knowledge of Systems and Signals, Proficiency in Python, C/C++.
References :
Main Text Books:
Kevin Zhou, Medical Image Recognition, Segmentation

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 211 (AUG) 3 : 0

Human Resource Management

Historical development - welfare to HRM in India. Personnel functions of management. Integrated HRPD system, human resource planning, job analysis,recruitment and selection, induction, performance appraisal and counseling,career planning and development, assessment center, wage and salaryadministration, incentives, benefits and services. Labour legislation - Industrial Disputes Act, Indian Trade Unions Act, Industrial Employment (Standing Orders) Act, dealing with unions, workers participation and consultation, grievance handling, employee relations in a changing environment, occupational health and safety, employee training and management development,need analysis and evaluation, managing organizational change and development.Personnel research, human resource management in the future.

Parthasarathy Ramachandran

Pre-requistes : None

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

MG 212 (AUG) 2 : 1

Behavioral Science

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

Anjula Gurtoo

Pre-requistes : None

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

MG 225 (AUG) 3 : 0

Decision Models

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

Parthasarathy Ramachandran

Pre-requistes : None

References : None

MG 241 (AUG) 3 : 0

Marketing Management

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

Parthasarathy Ramachandran

Pre-requistes : None

References : None

MG 258 (AUG) 3 : 0

Financial instruments and risk management strategies

Shashi Jain

Pre-requistes : None

References : None

MG 265 (AUG) 3 : 0

Data Mining

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

Parthasarathy Ramachandran

Pre-requistes : None

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

MG 298 (AUG) 3 : 0

Entreperneurship for Technology Start-ups

Bala Subrahmanya Mungila Hillemane

Pre-requistes : None

References : None

MG 229 (AUG) 3 : 0

Regression and Time Series Analysis

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

Mukhopadhyay C

Pre-requistes : MG220 or equivalent

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

MG 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

ER 201 (AUG) 3 : 0

Renewable Energy Technologies

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

Pradip Dutta

Pre-requistes : None

References : None

ER 207 (AUG) 3 : 0

Optimal design of energy systems

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

Jaichander Swaminathan

Pre-requistes : None

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

Water Research

Preface

WR 201 (AUG) 2 : 1

Watershed Modeling

Course description: This course will cover the concepts of watershed modeling. This three-credit course will be offered as an elective every year in the August-December term in the ICWaR. This course is aimed to be an introductory graduate-level (200-series) course, typically with Water Resources Engineering background. In-class lectures include basic and advanced topics related to surface hydrology. Additionally, the basics of computer methods in hydrology will be discussed. Tutorial sessions on MATLAB, MS Excel, and ArcSWAT will be conducted. Calibration and validation of ArcSWAT (distributed model) and HYMOD (lumped model) will be performed during tutorial sessions.

Topics
1. Introduction to watershed modeling
Runoff generation and streamflow. Spatio-temporal scales in watershed modeling. Watershed properties.

2. Pre-processing of model inputs
Understanding watershed model inputs. Basics of MATLAB computations. Hydrologic data processing in MATLAB.

3. Data-driven watershed models
Stochastic models (ex: Quantile regression). Neural network models.

4. Different watershed models
Lumped/ Distributed/ Physical/ Conceptual watershed models. Thornwaite-type water balance model. Thomas model (abcd) model. Data assimilation in abcd model. Introduction to ArcSWAT and HYMOD. Flood forecasting. Performance measures.

5. Predicting the future
Future hydrologic projections. Impact of climate change on river discharge. Uncertainty in river discharge estimation.

Tutorial Sessions
Processing of Geospatial and temporal data for watershed modeling. MATLAB tutorials. ‘abcd’ model set-up in MS Excel. Stochastic and NN model setup in Matlab. Calibration and validation of HYMOD and ArcSWAT. Development of forecast models.

Rajarshi Das Bhowmik

Pre-requistes : Nona

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

WR 202 (AUG) 3 : 0

Geodetic signal processing

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

Bramha Dutt Vishwakarma

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

References :
1. Torge, W., & Müller, J. (2012). Geodesy. In Geodesy. de Gruyter.
2.

WR 203 (AUG) 2 : 1

Applied geochemical modeling and Water quality analysis

Simulation and modelling
- Introduction to the Storm Water Management Model (SWMM) in Urban Catchments (4 hr)
- Tutorial on BRAT (Basic Radar Altimetry Toolbox) (4 hr)
- Tutorial on Remote Sensing (4 hr)
- Introduction to Climate/Earth System Modeling (4 hr)

Basic electronic instrumentation (6 hr)

Measurements of ionic contaminants using an ICPMS and IC (6 hr)

Water Quality (1 hr)

- To assess the alkalinity of a given water sample. (1 hr)
- Determine chloride ion concentration in a water sample. (1 hr)
- To assess the total solids of a given sample of water. (1 hr)
- Measure Total hardness using dye indicators. (1 hr)
- To introduce concepts of total coliforms using the multiple-tube fermentation technique. (2 hr)
- To assess the color of the given water sample. (1 hr)
- Determine the DO content of a given sample. (1 hr)
- To assess the pH value of the given water samples. (1 hr)
- To assess the residual chlorine of the given water sample. (1 hr)

Praveen Ramamurthy

Pre-requistes : None

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

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

Cyber Physical Systems

Preface

CP 212 (AUG) 2 : 1

Design of Cyber-Physical Systems

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

Bharadwaj Amrutur

Pre-requistes : None

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

CP 214 (AUG) 3 : 1

Foundations of Robotics

NOTE: This course is cross-listed with CSA (soft core for CSA) Motivation and objective: As we see an increasing use of industrial and service robots around us, there is a need for development of new skills in the field of robotic systems. More importantly, there is a need for development of new expertise in controllers, systems, sensors and algorithms that are tailored for the domain of robotic systems. Therefore, the objective of this course is to serve as an introductory robotics course for EECS students with little/no background in mechanical systems. The course will first build the necessary mathematical framework in which to understand topics relevant to fundamentals of mechanical systems. Some of the topics are center of gravity and moment of inertia, friction, statics of rigid bodies, principle of virtual work, kinematics of particles and rigid bodies, impacts, Newtonian and Lagrangian mechanics. With these fundamentals, the course will focus on topics like rigid body trans

Shishir Nadubettu Yadukumar

Pre-requistes : None

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

CP 220 (AUG) 2 : 1

Mathematical Techniques for Robotics Systems

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

Bharadwaj Amrutur

Pre-requistes : None

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

CP 318 (AUG) 2 : 1

Data Science for Smart City Applications

Data types, data pre-processing (filtering, discretization, standardization, transformation, Imputation etc.), Regression, spatio-temporal estimation (kriging, Gaussian process regression etc.), data dissimilarity measures, Pattern discovery (frequent pattern mining, clustering (event, time-series, trajectory clustering, spatio-temporal clustering etc.), Classification (logistic regression, SVM, Ensembles), Anomaly/Outlier Detection, Concepts for big data mining and visualizations (sampling techniques, dimension reduction (PCA, Manifold learning.)), semi-supervised learning, active learning, Concepts for stream data mining.

Punit Rathore

Pre-requistes :
Basic knowledge of Linear Algebra, Probability, and Calculus, and Basic Programming knowledge (preferably in Python)

References :
Pattern Recognition and Machine Learning, Christopher Bishop, New York, Springer, 2006

CP 232 (AUG) 2 : 1

Swarm Robotic System

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

Suresh Sundaram , Jishnu Keshavan

Pre-requistes :
Undergraduate Engineering Mathematics courses that include: vectors, linear algebra, differential equations, facility with computers (This
References : 1. Instructor's lecture notes
2. Autonomous Robots, George Bekey, MIT Press, 2006.
3. Heiko Hamann, Space Time Continuous Models of Swarm Robotic Systems, Springer 2010

CP 250 (AUG) 3 : 0

Energy Informatics

This course is focused on teaching students about energy cyber-physical systems and various modeling techniques for demand-side energy management in built environments. The primary focus is on how to develop energy models and how they can be used to understand and optimize various types of energy use by different subsystems, such as lighting, cooling, and heating, at different scales. Special emphasis will be placed on the practical application of these techniques using real systems and energy datasets. The course will cover the following main topics:
• Introduction to energy cyber-physical systems and demand-side energy management in built environments.
• Fundamental principles of energy modeling and optimization.
• Modeling of energy use and by different subsystems, such as lighting, cooling, and heating
• Different scales of modeling, including building-scale, neighborhood-scale, and city-scale models and simulations.
• Use of real energy datasets for model development and validation.
• Energy forecasting with time series analysis (e.g., ARIMA) and neural network-based models (e.g., RNN and LSTM).
• Practical application of modeling techniques such as demand forecasting, energy prediction, and load pattern analysis.

Pandarasamy Arjunan

Pre-requistes :
There are no prerequisites for this course except for having basic programming knowledge.
References : 1. Building Energy Modeling with OpenStudio (2018) by Larry Brackney, Andrew Parker, Daniel Macumber, and Kyle Benne
2. Energy Systems Modeling: Principles and Applications (2019) by Hooman Farzaneh
3. Applied Data Analysis and Modeling for Energy Engineers and Scientists (2011) by T. Agami Reddy

CP 320 (AUG) 3 : 0

Operations Research for Mobility Management

This course will introduce operations research (OR) techniques applied to cyber-physical systems (CPS), with an emphasis on decision making for mobility management. Urban mobility is evolving from a fixed supply chain that delivers process-driven travel to a dynamic ecosystem that delivers on-demand services. This new mobility model requires optimization across multiple systems such as transportation, parking, electric vehicle charging and vehicle-to-grid services, etc. The complexity, therefore, arises from the large scale of operations; heterogeneity of system components; dynamic and uncertain operating conditions; and goal-driven decision making and control with time-bounded task completion guarantees.

The focus in this course will be on various classical optimization techniques and learning to optimize approaches that can be applied to solve operational problems at scale in the urban mobility domain. Examples of some decision questions include planning/scheduling charging operations for a fleet of electric vehicles; dynamic pricing for charging demand management; electric vehicle route planning for last-mile delivery of goods and other valued-added services (such as selling energy back to the grid); operations management of mixed fleet of vehicles; etc. Selective operations research topics such as linear programming and combinatorial optimization; dynamic programming; sequential decision making under uncertainty; reinforcement learning; etc.; will be covered to understand the mathematical concepts for problem solving in mobility management.

This course will be relevant to both computer science and electrical engineering students, as well as benefit those specializing in cyber physical systems and sustainable transportation.

Punit Rathore

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

References :

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

CP 241 (AUG) 2 : 1

Applied Linear and Nonlinear Control

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

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

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

Vaibhav Katewa , Pushpak Jagtap

Pre-requistes :
None

References :

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

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 201 (AUG) 3 : 0

Flight and Space Mechanics

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

Ramesh O N

Pre-requistes : None

References : Anderson, J.D. Jr., Introduction to Flight, Fifth Edition, McGraw Hill Higher Education 2007.

AE 202 (AUG) 3 : 0

Fluid Dynamics

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

Duvvuri Subrahmanyam

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.

Irfan Ahmed Mulla

Pre-requistes : None

References :
Philip G. Hill and Carl R. Peterson. "Mechanics and thermodynamics of propulsion." Reading, MA, Addison-Wesley Publishing Co., 1992~Nicholas

AE 204 (AUG) 3 : 0

Flight Vehicle Structures

Introduction to aircraft structures and materials; introduction to elasticity,torsion, bending and flexural shear, flexural shear flow in thin-walled sections; elastic buckling; failure theories; variational principles and energy methods; loads on aircraft.

Debiprosad Roy Mahapatra

Pre-requistes : None

References : Sun, C.T., Mechanics of Aircraft Structures, John Wiley and Sons, New York,2006~Megson, T.H.G., Aircraft Structures for Engineering Students, Butterworth- Heinemann, Oxford, 2013.~Lecture notes.

AE 205 (AUG) 3 : 0

Navigation, Guidance and Control

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

Ashwini Ratnoo , Suresh Sundaram

Pre-requistes : None

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

AE 228 (AUG) 2 : 1

Computation of Viscous Flows

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

Balakrishnan N(CFD)

Pre-requistes : None

References : None

AE 230 (AUG) 3 : 0

Aeroelasticity

Effect of wing flexibility on lift distribution; Torsional wing divergence;Unsteady aerodynamics of oscillating wing; Bending-torsion flutter of wing sections and wings; Stall flutter, panel flutter, and transonic flutter; Gust response of elastic airplane; Aeroservoelasticity; Aeroelastic effects on aircraft stability derivatives; Flight dynamics and aeroelasticity

Kartik Venkatraman

Pre-requistes : None

References : None

AE 250 (AUG) 3 : 0

Advanced Combustion

Pratikash Prakash Panda

Pre-requistes : None

References : None

AE 261 (AUG) 3 : 0

Structural Vibration Control

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

Siddanagouda Kandagal

Pre-requistes : None

References :
Ewins, D.J., Modal analysis: Theory and Practice, Research Studies Press Ltd., England, 2000.~Clarence W. de Silva, Vibration: Fundamentals and

AE 291 (AUG) 3 : 0

Special topics in aerospace engineering 1

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

Srisha Rao M V , Viveknand Dabade , Rajesh Chaunsali , Aravind Balan

Pre-requistes : None

References : None

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.

Viveknand Dabade

Pre-requistes : None

References : None

Atmospheric and Oceanic Sciences

Preface

AS 203 (AUG) 3 : 0

Atmospheric Thermodynamics

Vertical structure and composition of the atmosphere, kinetic theory of gases,first and second principles of thermodynamics, thermodynamics of dry air,concept of saturation vapour pressure, water vapour in the atmosphere,properties of moist air, isobaric and isothermal processes, atmospheric stability, parcel and area methods, nucleation, effect of aerosols, clouds and precipitation, forms of atmospheric convection.

Arindam Chakraborty

Pre-requistes : None

References : Iribarne, I.V., and Godson, W.I., Atmospheric Thermodynamics, 2nd Edn, D Reidel Publishing Company, 1971,Rogers, R.R., A Short Course in Cloud Physics,2nd Edition, Pergamon Press, 1979,Bohren, C.F., and Albhecht, B.A.,Atmospheric Thermodynamics, Oxford University Press, 1998,Tsonis, A.A., An Introduction to Atmospheric Thermodynamics, Cambridge University Press, 2002,Wallace,

AS 205 (AUG) 2 : 1

Ocean Dynamics

Introduction to physical oceanography, properties of sea water and their distribution, mixed layer, barrier layer, thermocline, stratification and stability, heat budget and air-sea interaction, ocean general circulation, thermohaline circulation, basic concepts and equations of motion, scale analysis, geostrophic currents, wind-driven ocean circulation, Ekman layer in the ocean, Sverdrup flow, vorticity in the ocean, waves in the ocean, surface gravity waves, Rossby and Kelvin waves.

Vinayachandran P N

Pre-requistes : None

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

AS 207 (AUG) 3 : 0

Introduction to Atmospheric Dynamics

Jai Suhas Sukhatme

Pre-requistes : None

References : None

AS 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 308 (AUG) 2 : 1

Ocean Modeling

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

Vinayachandran P N

Pre-requistes : None

References : None

AS 215 (AUG) 3 : 0

Environmental Fluid Dynamics

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

Bishakhdatta Gayen

Pre-requistes : None

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

Earth Sciences

Preface

ES 204 (AUG) 3 : 0

Origin and Evolution of the Earth

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

Ramananda Chakrabarti

Pre-requistes : None

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

ES 205 (AUG) 3 : 0

Mathematics for Geophysicists

Vector fields: basic vector algebra, line, surface and volume integrals, potential, conservative fields, gradient, divergence, curl, circulation, Stokes's theorem, Gauss's theorem, applications in fluid mechanics and electromagnetism, Kelvin's theorem, Helmholtz's theorem. Linear algebra: Matrices, operations, eigen components, systems of linear differential equations, examples. Partial differential equations: The diffusion equation,wave equation, Laplace's equation, Poisson's equation, similarity solutions,numerical solutions (simple examples with MATLAB), series solutions, spherical harmonic expansions. Dimensional analysis: Pi theorem, similarity,nondimensional formulation of geophysical problems, examples.

Binod Sreenivasan

Pre-requistes : None

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

ES 215 (AUG) 3 : 0

Introduction to Chemical Oceanography

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

Sambuddha Misra

Pre-requistes : None

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

ES 206 (AUG) 3 : 0

Solid Earth Geophysics

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

Attreyee Ghosh

Pre-requistes : None

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

ES 218 (AUG) 3 : 0

Introduction to Seismology

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

Pawan Bharadwaj Pisupati

Pre-requistes : None

References :

Aki, Keiiti, and Paul G. Richards. Quantitative seismology. Chapman,

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.,

ST 214 (AUG) 3 : 0

Mathematical Analysis of Experimental Data

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

Lakshminarayana Rao M P

Pre-requistes : None

References :

Douglas C. Montgomery, Design and Analysis of Experiments (2012), John Wiley and Sons, Inc.~Box, G. E. P., Hunter, W. G., and Hunter, J. S.

ST 216 (AUG) 3 : 0

Physics in Experiments with Classical Statistics

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

Punit Singh

Pre-requistes : None

References :

[1] Barenblatt. G. I, 'Scaling', Cambridge Texts in Applied Mathematics, (2003) [2] Holman J. P., Experimental Methods for Engineers, Mcgraw-Hill

ST 217 (AUG) 3 : 1

Field hydrology, river engineering and basin studies

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

Punit Singh

Pre-requistes : None

References :

[1] Barenblatt. G. I, 'Scaling', Cambridge Texts in Applied Mathematics, (2003) [2] Holman J. P., Experimental Methods for Engineers, Mcgraw-Hill

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

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.

Ganapathy Ayappa

Pre-requistes : None

References : None

CH 246 (AUG) 3 : 0

Advanced Process Control

Jayant M Modak

Pre-requistes : None

References : None

CH 252 (AUG) 3 : 0

Hydroprocessing

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

Venugopal S

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

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

Civil Engineering

Preface

CE 247 (AUG) 3 : 0

Remote Sensing and GIS for Water Resources Engineering

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

Nagesh Kumar D

Pre-requistes : None

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

CE 201 (AUG) 3 : 0

Basic Geo-mechanics

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

Swetha Veeraraghavan

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

Debraj Ghosh

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

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

Manohar C S

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 211 (AUG) 3 : 0

Water Quality Modelling

Sekhar M

Pre-requistes : None

References : None

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.

CE 236 (AUG) 3 : 0

Fracture Mechanics

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

Remalli Vidya Sagar

Pre-requistes : None

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

CE 243 (AUG) 3 : 0

Bridge Engineering

Ananth Ramaswamy

Pre-requistes :
Solid Mechanics (CE 204 or equivalent)

References : None

CE 249 (AUG) 3 : 0

Water Quality Modeling

Basic characteristics of water quality, stoichiometry and reaction kinetics.Mathematical models of physical systems, completely and incompletely mixed systems. Movement of contaminants in the environment. Water quality modeling in rivers and estuaries - dissolved oxygen and pathogens. Water quality modeling in lakes and ground water systems.

Sekhar M

Pre-requistes : None

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

CE 274 (AUG) 3 : 0

Seismic Analysis and Design of Structures

Nanjunda Rao K S

Pre-requistes : None

References : None

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 275 (AUG) 3 : 0

Transportation Systems Modelling

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

Abdul Rawoof Pinjari

Pre-requistes : None

References : J. de D. Ortuzar and L.G. Willumsen. Modelling Transport (4th edition), John Wiley and Sons, 2011.~F. Koppelman and C.R. Bhat. A Self Instructing Course in Mode Choice Modeling: Multinomial and Nested Logit Models, 2006.

CE 284 (AUG) 3 : 0

Plates, Shells, and Geometric Elasticity

Brief review of elasticity and variational principles. Classical plate theories: Elements of plate deformation; pure bending of thin circular and rectangular plates under various boundary conditions; Navier and Lévy solutions; introduction to plates of general shapes; problems in combined lateral and membrane loading in thin rectangular and circular plates. Introduction to Mindlin-Reissner shear plates; elements of large deflection of thin plates and the Fóppl-von Kármán equations. Introduction to stability and plate buckling. Applications of plate theories. Brief introduction to the differential geometry of surfaces; First and second fundamental forms; principal curvatures; Gauss curvature. Shell theories: General Kirchhoff-Love linear theory of thin shells; membrane theory of shells for cylindrical shells and shells of revolution; engineering applications. Introduction to computational methods for shell and plate problems. Other topics as time permits (orthotropic plates; plates.

Narayan K Sundaram

Pre-requistes :
Graduate-level solid mechanics (CE 204 / ME 242 or equivalent), or instructor consent.

References : (1) Ventsel and Krauthammer, Thin Plates and Shells: Theory, Analysis and Applications (2) Timoshenko and Woinowsky-Krieger, Theory of Plates and Shells (3) Villagio, Mathematical Models for Elastic Structures (4) Historical and current literatur

CE 250 (AUG) 3 : 0

Stability and Design of Steel Structures

Introduction, Limit state design philosophy of reinforced concrete, Stress-strain behavior in multi-axial loading, failure theories, plasticity and fracture, ductility, deflections, creep and shrinkage, Strength of RC elements in axial, flexure, shear and torsion, RC columns under axial and eccentric loading, Beam-column joints, Strut and Tie modelling, Yield line theory of slabs, Seismic resistant design, Methods for predicting the behavior of pre-stressed concrete members and structures. Concepts and principles of stability of beam-columns- Differential equations for beam-columns, effects of concentrated lateral loads, effects of different end conditions such as built-in or elastic supports; continuous beams and columns with axial loads, torsion in Thin walled sections, Lateral buckling of beams, elastic buckling of rigid frames, arches; influence of material inelasticity and imperfections in the structural stability of member ; application of energy and numerical methods in critica.

Ananth Ramaswamy

Pre-requistes :
Solid Mechanics (CE 204 or equivalent)

References : Nilson, A. H., Darwin, D. and Dolan, C. W., Design of concrete structures,McGraw Hill, 2004~ Lin and Burns, Design of Prestressed concrete structures,John Wiley and Sons, 2006~ Agarwal and Shrikhande- Earthquake resistant design of structures, Prentice-Hall of India Pvt. Ltd. New Delhi, 2006. 1. Temoshenko, S. and Gere, J., "Theory of Elastic Stability" McGraw Hill. 2. Wai-Fa Chen and Lui,

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 , Tejas Gorur Murthy

Pre-requistes : None

References :
1. Engineering Rock Mechanics. John A. Hudson and John P. Harrison.
2.

CE 202A (AUG) 2 : 1

Integrated Investigation of Dams

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

Anbazhagan P

Pre-requistes : None

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

CE 203A (AUG) 3 : 0

Hydrologic Safety Evaluation of Dams

Significance of hydrologic safety evaluation and modeling, uncertainty in hydro-meteorological processes; Standard project storm and Probable maximum precipitation (PMP); Design flood estimation - Hydro-meteorological approach: unit hydrograph construction, design storm depth estimation from PMP Atlas, storm transposition and adjustment, estimation of loss rate, base flow and time distribution coefficients, HEC-HMS model; Flood frequency analysis approach: At-site and regional frequency analysis using commonly used probability distributions in hydrology, Probability plotting and Goodness of fit tests; Reservoir sedimentation, Reservoir rule curve.

Srinivas V V

Pre-requistes : None

References : Chow, V.T., Maidment, D.R. and Mays, L.W., Applied Hydrology, McGraw-Hill, 1988.
Handbook for Assessing and Managing Reservoir Sedimentation, Dam Safety Rehabilitation Directorate, Central Water Commission, 2019.
Hosking, J. R. M., and Wallis, J. R., Regional Frequency Analysis: An Approach Based on L-Moments, Cambridge University Press, 1997.

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 250 (AUG) 3 : 0

Introduction to Materials Science and Engineering

Subodh Kumar

Pre-requistes : None

References : None

MT 253 (AUG) 3 : 0

Mechanical Behaviour of Materials

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

Praveen Kumar

Pre-requistes : None

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

MT 260 (AUG) 3 : 0

Polymer Science and Engineering

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

Suryasarathi Bose

Pre-requistes : None

References : None

MT 261 (AUG) 3 : 0

Organic Electronics

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

Praveen Ramamurthy

Pre-requistes : None

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

MT 271 (AUG) 3 : 0

Introduction to Biomaterials Science and Engineering

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

Kaushik Chatterjee

Pre-requistes : None

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

MT 245 (AUG) 3 : 0

Transport Processes in Process Metallurgy

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

Govind S Gupta

Pre-requistes : None

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

MT 211 (AUG) 3 : 0

Magnetism, Magnetic Materials, and Devices

Fundamentals: Classical and quantum mechanical pictures of magnetism; spin orbit coupling, crystal field environments, diamagnetism, paramagnetism, ferromagnetism, antiferromagnetism, dipolar and exchange interactions, magnetic domains, magnetic anisotropy, magnetostriction, superparamagnetism, biomagnetism, and spin glass

Bulk magnetic Materials: Transition and rare earth metals and alloys. Oxide based magnetic materials. Hard, soft and magnetostrictive materials, Magnetic shape memory alloys, Structure-microstructure-magnetic property correlations.

Low dimensional Magnetic systems and devices: Magnetic nanostructures, thin films, and epitaxial heterostructures; exchange bias and exchange coupling, and magneto-optical materials and devices, AMR, GMR, TMR, spin-transfer torque, spin-orbit torque and spin-Hall effect; Multiferroics, magnetoelectric and magnetoionics; nonvolatile magnetic memory, synaptic and neuromorphic computing devices;

Experimental techniques: VSM, SQUID, Mossbauer, MFM, Magneto-transport, Magnetooptical Kerr-effect, XMLD and XMCD.

Bhagwati Prasad

Pre-requistes : None

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

MT 217 (AUG) 3 : 0

Computational Mathematics for Materials Engineers

Vector and tensor algebra; Basics of linear algebra and matrix inversion methods; Coordinate transformations methods; Optimization methods,
Probability and statistics; Numerical methods: Concepts of discretization in space/time, implicit, explicit; Solution to ODEs(Euler, Heun, Runge-Kutta methods), PDEs (Elliptic, Parabolic, Hyperbolic), solutions to Laplace equation and applications, transient diffusion and wave equation; Discretization methods (FDM, FVM, FEM); iterative solution schemes Jacobi, Gauss-Seidel, ADI, Multigrid, Fourier-spectral schemes; Root finding methods, interpolation, curve-fitting, regression; Special functions: Bessel, Legendre, Fourier, Laguerre, etc;

Computational tools for the solution to all the above problems will be discussed along with canonical examples from materials problems. Software tools, based on python and/or MATLAB, will also be introduced in the course.

Instructor: A N Choudhury and S. Gautam G

Abhik N Choudhury , Sai Gautam Gopalakrishnan

Pre-requistes : None

References : Books: Advanced Engineering Mathematics; Erwin Kreyzig
Mathematical physics (V. Balakrishnan)
Numerical methods for Engineers(Steven C. Chapra and Paymond P. Canale)

MT 307 (AUG) 3 : 0

Materials in Extreme environments

Overview of engineering systems under extreme environment

Background review: Materials response under low and high temperature: Microstructure and atomic structure, defects, Materials response under quasistatic loadings (tensile, fracture and fatigue), strengthening mechanisms, Effect of temperature on microstructure and properties, Creep, high-temperature fatigue

Materials response under mechanical extremes: Loading states, Elastic waves in solids, Shock loading, Distance-time diagrams, Static high-pressure devices, Platforms for loading at intermediate strain rates, Platforms for shock and quasi-isentropic loading, Shock compression of FCC, BCC and HCP metals, Amorphous metals, Phase transformations, Plasticity in compression, Ramp loading, Release, Spallation and Failure, Adiabatic shear, Response of Ceramics

Materials response under Irradiation: Irradiation basics, Irradiation-Processes Leading to Extreme Situations, Irradiation Using Different Incident Beams, Defect Dynamics in Materials Under Irradiation, Irradiation-Enhanced Diffusion, Irradiation-Induced Segregation, Radiation-Induced/Enhanced Phase Transformation, Influence of Radiation-induced Microstructure on Mechanical Properties

Materials in Hostile corrosive environment: Introduction, Corrosion by Liquid Sodium, Materials for the Hostile Corrosive Environments in Steam Water Environments, Materials in Seawater Environment

Ankur Chauhan

Pre-requistes : None

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

MT 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

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 , Gaurav Tomar

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 rectangular and polar coordinates, axisymmetric problems, energy methods, St. Venant torsion,elastic wave propagation, elastic instability and thermal stresses.

Ramsharan Rangarajan , Debashish Das

Pre-requistes : None

References : None

ME 243 (AUG) 3 : 0

Continuum Mechanics

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

Chandrashekhar S Jog

Pre-requistes : None

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

ME 255 (AUG) 3 : 0

Principles of Tribology

Surfaces, theories of friction and wear, friction and wear considerations in design, viscosity, hydrodynamic lubrication, Reynolds equation, coupling of elastic and thermal equations with Reynolds equation. Elasto-hydrodynamic lubrication. Mechanics of rolling motion, hydrostatic lubrication, lubricants,tribometry, selection of tribological solutions.

Bobji M S

Pre-requistes : None

References : None

ME 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 , Koushik Viswanathan , Shubhadeep Mandal

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 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.

Balachandra Suri

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

Ananthasuresh G K

Pre-requistes : None

References :
NPTEL MOOC: https://nptel.ac.in/courses/112/108/112108201/~Haftka, R. T. and Gurdal, Z., "Elements of Structural Optimization," Kluwer Academic

ME 226 (AUG) 3 : 0

Applied Dynamics I

Part A: Tools for analysis of planar mechanisms. A 2D mechanism is a collection of rigid objects interacting with each other or to the fixed environment via hinges, sliding connections, collisions, springs, dashpots, non-holonomic constraints (rolling or skates) or body forces (e.g. gravity). Part B: Analysis of motion of a single rigid object in 3D using dyads for representation of rotation and inertia tensors. Special cases of 3D motion including fixed axes rotation (static and dynamic balance), steady precession of axisymmetric objects, stability of rotation about a principle axis, and chaotic motions of a mass suspended by a spring.

Jishnu Keshavan

Pre-requistes :
Undergraduate Engineering Mathematics courses that include: vectors, linear algebra, differential equations, facility with computers (This

References :
1. Instructor's notes and lecture videos.
2. Classical Mechanics,

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 scipy.sparse.linalg modules
• Constrained and unconstrained optimization problems - Lagrange multipliers, linear programming, quadratic programming,
• Convex sets, functions and types of convex optimization problems - getting started with CVX_OPT/ CVX_PY
• Discrete and continuous random variables. Bayes’ rule, Gibbs sampling, Bayesian inference - getting started with pymc

Navaneetha Krishnan Ravichandran , 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/]

Product Design and Manufacturing

Preface

MN 201 (AUG) 3 : 0

Materials and Processes

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

Satish V Kailas , Satyam Suwas

Pre-requistes : None

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

MN 202 (AUG) 3 : 0

Digital Manufacturing

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

Ashitava Ghosal , Gurumoorthy B , Dibakar Sen

Pre-requistes : None

References : None

MN 205 (AUG) 1 : 2

Makers’ Project

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

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.

Shivakumar N D , Vishal Singh

Pre-requistes : None

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

PD 202 (AUG) 2 : 1

Elements of Solid and Fluid Mechanics

Analysis of stress and strain, failure criteria, dynamics and vibrations. Control of engineering systems, elements of fluid mechanics drag and losses, thermal analysis, problems in structural and thermal design.

Gurumoorthy B , Manish Arora

Pre-requistes : None

References : Shigley, J.E., Mechanical Engineering Design, McGraw Hill.,White, F.M., Fluid Mechanics, Tata McGraw Hill.,Gupta, V., Elements and Heat and Mass Transfer, Sage Publishers.

PD 203 (AUG) 2 : 1

Creative Engineering Design

Design: definitions, history and modern practice. Design and society, design and the product life cycle. Methodology for problem solving in engineering design: recognition, definition, analysis, synthesis, communication and presentation. Hands-on projects.

Amaresh Chakrabarti , Vishal Singh

Pre-requistes : None

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

PD 207 (AUG) 1 : 2

Product Visualization, Communication and Presentation

Object drawing fundamentals, theory of perspectives, exploded views, sectional views. Fundamentals of lighting, idea representation and communication methods and pitfalls. Materials, tools and techniques of representation in various media like pencil, ink, colour etc. Rendering techniques, air brush illustration. Idea documentation. Fundamentals of photography, video-graphy and digital media. Dark room techniques. Studio assignments in all the above topics. Mock-up modeling and simulation in various materials.

Shivakumar N D , Vishal Singh

Pre-requistes : None

References : Geometry of design: Studies in proportion and composition, ISBN: 1568982496,Foundation of Art & Design 1856693759,Earle,J.E.,Engineering Design Graphics, Addison Wesley, ISBN 020111318x

PD 209 (AUG) 2 : 1

New Product Development: Concepts and Tools

Technology-based products, business context, front-end of innovation, opportunity identification, target markets, integrated teams, product features, differentiation from competition, business cases, product architecture,designing and prototyping products, planning for manufacturing capabilities,marketing and sales programs

Gurumoorthy B

Pre-requistes : None

References : (1) Ulrich, K.T., and Eppinger, S.D., Product Design and Development, 2nd edition, (2) Philip Kotler, Kevin Lane Keller,Marketing Management, 15th edition, (3) Douglas Smith and Jon Katzenbach, The Wisdom of Teams: Creating the High-Performance Organization, 2015 edition.

PD 217 (AUG) 2 : 1

CAE in Product Design

Product development driven by concurrent engineering, role of Computer- AidedEngineering (CAE) in product design. Mathematical abstractions of products for functionality verification; lumped mass,finite element, boundary element, and statistical modeling procedures.Use of commercial finite element-based packages for design analysis and optimization.

Anindya Deb

Pre-requistes : None

References : Bathe, K.J., Finite Element Procedures, Prentice Hall,1995.,Robert Cook,Finite Element Modeling for Stress Analysis,1995.,Banerjee, P.K., Boundary Element Methods in Engineering Science, McGraw Hill.

PD 229 (AUG) 0 : 3

Computer Aided Product Design

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 Analysis of stress and strain, failure criteria, dynamics and vibrations. Control of engineering systems, elements of fluid mechanics drag and losses, thermal analysis, problems in structural and thermal design. Project in re-engineering a product using computer tools for reverse engineering geometry and intent, design evaluation, modification and prototyping.

Ashitava Ghosal , Gurumoorthy B

Pre-requistes : None

References : Shigley, J.E., Mechanical Engineering Design, McGraw Hill.,White, F.M., Fluid Mechanics, Tata McGraw Hill.,Gupta, V., Elements and Heat and Mass Transfer, Sage Publishers.

PD 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 232 (AUG) 2 : 1

Human Computer Interaction

Basic theories of visual and auditory perception, cognition,rapid aiming movement and their implications in electronic user interface design, Concept of user modelling, Multimodal interaction,Eye gaze and finger movement controlled user interface, Target prediction technologies in graphical user interface, usability evaluation, User study design, Basic principles of experiment design,Conducting t-test and one-way and repeated measure ANOVA,Parametric and nonparametric statistics, Interaction design for automotive and aviation environments, HCI in India, Writing International standards through ITU and ISO.

Pradipta Biswas

Pre-requistes : None

References : Shneiderman B "Designing the User Interface - Strategies for Effective Human-Computer Interaction. " Pearson Education,Buxton B."Sketching User Experiences: Getting the Design Right and the Right Design",Field A. "Discovering Statistics Using SPSS." SAGE Publications Ltd.

PD 233 (AUG) 2 : 1

Design of Biomedical Devices and Systems

Medical Device Classification, Bioethics and Privacy, Biocompatibility and Sterilization Techniques,Design of Clinical Trials, Design Control & Regulatory Requirements, Introduction to specific medical technologies: Biopotentials measurement (EMG, EOG, ECG, EEG), Medical Diagnostics (In vitro diagnostics), Medical diagnostics (Imaging), Minimally Invasive Devices,Surgical Tools and Implants, Medical Records and Telemedicine. The course will include guest lectures by healthcare professionals giving exposure to ummet needs in the healthcare technologies and systems.

Manish Arora

Pre-requistes : None

References : Paul H king, Richard C. Fries, Arthur T. johnson, Design of Biomedical Devices and Systems. Third edition, ISBN 9781466569133,Peter J.Ogrodnik, Medical Device Design:Innovation from Concept to Market, Academic Press Inc; ! edition (2012), ISBN-10:0123919428,Stefanos Zenios, Josh Makower, Paul Yock, Todd J.Brinton, uday N. Kumar, Lyn Denend, Thomas

PD 239 (AUG) 0 : 3

Design and Society

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

Dibakar Sen

Pre-requistes : None

References : None

PD 299 (JAN) 0 : 16

Dissertation Project

Spread over 15 months, commencing immediately after the second semester. Itinvolves complete design and prototype fabrication with full documentation.

Dibakar Sen

Pre-requistes : None

References : None

PD 216 (AUG) 2 : 1

Design of Automotive Systems

Classification of automotive systems, interfacing of marketing, design and manufacturing, converting customer's needs into technical targets, vehicledesign process milestones with a systems engineering approach, trade-off studies, manufacturing cost and economic feasibility analysis. Design tools such as reverse engineering, rapid prototyping, CAD/CAE, Taguchi methods, andFMEA. Styling concepts and features, ergonomics, packaging and aerodynamics.Review of vehicle attributes (NVH,durability, vehicle dynamics, crash safety,etc.). Overview of automotive technology (body, power train, suspension systems, etc.).

Anindya Deb

Pre-requistes : None

References : Ulrich, K.T., and Eppinger, S.D., Product Design and Development, Second Edn, Irwin McGraw Hill,Gillespie, T.D., Fundamentals of Vehicle Dynamics, SAE Inc.., Schwaller, A.E., Motor Automotive Technology, Third Edn, Delman Publishers

PD 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

Rina Maiti , 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.

PD 206 (AUG) 2 : 1

Basics of Computing, AI and Data Science for Desig

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.

Pradipta Biswas , Vishal Singh , Abhijit Biswas

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

References :
• Roy Choudhury, D. (1988). Networks and Systems. India:Wiley Eastern.

MN 207 (AUG) 2 : 1

Intelligent Mobile Robots: Perception, Action and Control

Introduction to Mobile Robotics Locomotion Principles Kinematic Modelling Perception Control System Design Localization Motion Planning Multi-robot systems ROS and Matlab for Robotics Autonomy in Mobile Robot

Abhra Roy Chowdhury

Pre-requistes :

Familiarity with following is desired but not essential

References :
• H. Choset, K. M. Lynch, S. Hutchinson, G. Kantor, W. Burgard, L. E. Kavraki, and S. Thrun, Principles of Robot Motion: Theory, Algorithms and Implementations, PHI Ltd., 2005. • R. Siegwart, I. R. Nourbakhsh, Introduction to Autonomous Mobile Robots, MIT Press,2011 • G. Dudek and M. Jenkin, Computational Principles of Mobile Robotics, Cambridge University Press, 2010 • H. Asama, T.

MN 299 (JAN) 0 : 24

Dissertation Project

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

Dibakar Sen

Pre-requistes : None

References : -

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

High Energy Physics

Preface

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.

Justin Raj David

Pre-requistes : None

References :

Zee A.,Quantum Field Theory in a Nutshell (Second edition),Princeton University Press,2010~Srednicki M., Quantum Field Theory, Cambridge

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.

Asokan S , 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

Jayanth G R , Sai Siva Gorthi , Manish Arora , Asha Bhardwaj

Pre-requistes : None

References :
W. Bolton, Mechatronics, Longman, 2015~B.E.A. Saleh and M.C.Teich , Fundamentals of Photonics, John Wiley and Sons, 2007~D. Pozar, Microwave

IN 232 (AUG) 3 : 0

Concepts in solid state physics

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

Chandni U , Tapajyoti Das Gupta

Pre-requistes : None

References :
H. Ibach and H. Luth, Solid State Physics: An Introduction to Principles of Materials Science, Springer, 4th Edition 2009~Steven H. Simon, The Oxford

IN 302 (AUG) 3 : 0

Classical and Quantum Optics

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

Partha Pratim Mondal

Pre-requistes : None

References : None

IN 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 :

NA

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 :

None

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

IN 206 (AUG) 2 : 1

Signals and Systems for Digital Health

Digital Health - Introduction: Need, case studies, basics - mHealth and eHealth, Impact, Informatics: Health Level Seven (HL7), Integrating the Healthcare Enterprise (IHE), Vendor Neutral Archives (VNAs), Open source/ data/innovation – opportunities, Regulatory Affairs in Digital Health (FDA/DCGI), and Ayushman Bharat Digital Mission

Signals and Systems: Signals and Systems Review, LTI Systems, Signal Processing Review: DFT and its properties, Nyquist Sampling Theorem, Low-Pass Filtering, Filters - Chebyschev Filter and Butterworth Filter, Multi-resolution analysis, Filter Banks, Wavelets, Reconstruction of Bandlimited Signals.

Biomedical Signals and Systems: Basics of Physiology (brain, heart and muscle), ECG Signal Acquisition (Electrical activity of heart, chest leads/montage, action potential in pacemaker and other regions; action potential relation to ECG Waveform; Reading ECG); EEG Signal Acquisition (Neural activity in the brain, Action potential, post-synaptic potential, Signal Propagation in the brain, EEG montage, EEG Signal Acquisition); Basics of phonocardiography; EEG and ECG data processing, ECG and EEG signal processing (EEGLab).

Biomedical Wearable Devices: Wearable Sensors for health monitoring: Accelerometers (data acquisition and interpretation), glucose sensing (acquisition methods and comparison), Wearable ECG & EEG based on dry electrodes, pulse-oximeter. Medical regulatory approvals.

Jaya Prakash

Pre-requistes : None

References : 1) S. Haykin and B. V. Veen, “Signals and Systems”, 2nd Edition, Wiley Publisher (2007). 2) K. Najarian, and R. Splinter, “Biomedical Signal and Image Processing,” 2nd Edition, CRC Press (2012). 3) Journal Papers, Case Reports, and Review Articles

IN 280 (AUG) 2 : 1

Optical Instrumentation

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

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

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

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

Sai Siva Gorthi

Pre-requistes :
No Prerequisites. This is an introductory level course suitable for Students from Diverse Backgrounds: Undergrad, Int. PhD, BS-MS, Masters

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

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

Mathematics

Preface

MA 219 (AUG) 3 : 1

Linear Algebra

ector spaces: definition, basis and dimension, direct sums. Linear transformations: definition, the Rank-ity Theorem, the algebra of linear transformations. Dual spaces. Matrices. Systems of linear equations: elementary theory of determinants, Cramer's rule. Eigenvalues and eigenvectors, the characteristic polynomial, the Cayley-Hamilton Theorem, the minimal polynomial, algebraic and geometric multiplicities. Diagonalization. The Jordan canonical form. Symmetry: group of motions of the plane, discrete groups of motion, finite subgroups of SO(3). Bilinear forms: symmetric, skew-symmetric and Hermitian forms, Sylvester's law of inertia, Spectral theorem for Hermitian and normal operators on finite-dimensional vector spaces.

Apoorva Khare

Pre-requistes : None

References : Hoffman K. and Kunze R. Linear Algebra (2nd Ed.) Prentice-Hall of India. 1992. ~Artin M. Algebra. Prentice-Hall of India. 1994.~Halmos P. Finite dimensional vector spaces. Springer-Verlag (UTM). 1987.~Lang S. Linear Algebra (3rd Ed.) Springer-Verlag (UTM). 1989.

MA 232 (AUG) 3 : 0

Introduction to Algebraic Topology

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

Siddhartha Gadgil

Pre-requistes : None

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

MA 261 (AUG) 3 : 0

Probability Models

Sample spaces, events, probability, discrete and continuous random variables, Conditioning and independence, Bayes' formula, moments and moment generating function, characteristic function, laws of large numbers, central limit theorem, theory of estimation, testing of hypotheses, linear models.

Sanchayan Sen

Pre-requistes : None

References :
Ross,S.M.,Introduction to Probability Models,Academic Press 1993.,
Taylor~Taylor, H.M., and Karlin, S., An Introduction to Stochastic

MA 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.

Radhika Ganapathy

Pre-requistes : None

References : None

MA 313 (AUG) 3 : 0

Algebraic Number Theory

Number fields and rings of integers, Dedekind domains; prime factorization,ideal class group, finiteness of class number, Dirichlet's unit theorem,cyclotomic fields, theory of valuations, local fields.

Mahesh Ramesh Kakde

Pre-requistes : None

References :
Jurgen Neukirch, Algebraic Number theory, Springer, 1999~Daniel A. Marcus,Number fields, Springer Universitext, 2018~J.P Serre, Local

MA 317 (AUG) 3 : 0

Introduction to Analytic Number Theory

Soumya Das

Pre-requistes : None

References : None

MA 341 (AUG) 3 : 0

Matrix Analysis and Positivity

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

Apoorva Khare

Pre-requistes : None

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

MA 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

MA 200 (AUG) 3 : 1

Multivariable Calculus

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

Vamsi Pritham Pingali

Pre-requistes : None

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

MA 212 (AUG) 3 : 0

Algebra I

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

Bharathwaj Palvannan

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 221 (AUG) 3 : 0

Analysis I

Construction of the field of real numbers and the least upper-bound property.Review of sets, countable & uncountable sets. Metric Spaces: topological properties, the topology of Euclidean space. Sequences and series. Continuity:definition and basic theorems, uniform continuity, the Intermediate Value Theorem. Differentiability on the real line: definition, the Mean Value Theorem. The Riemann-Stieltjes integral: definition and examples, the Fundamental Theorem of Calculus. Sequences and series of functions, uniform convergence, the Weierstrass Approximation Theorem. Differentiability in higher dimensions: motivations, the total derivative, and basic theorems.Partial derivatives, characterization of continuously-differentiable functions. The Inverse and Implicit Function Theorems. Higher-order derivatives.

Tirthankar Bhattacharyya

Pre-requistes : None

References : Rudin W. Principles of Mathematical Analysis. 3rd edition. McGraw-Hill International Edition.~Tao T. Analysis I. 3rd edition. TRIM series. Hindustan Book Agency. 2014.~Tao T. Analysis II. 3rd edition. TRIM series. Hindustan Book Agency. 2014.~Apostol T. M. Mathematical Analysis. Narosa. 1987.

MA 354 (AUG) 3 : 0

Topics in Number Theory

Galois representations:

The goal of this course is to give an introduction to the theory of Galois representations. Here is a list of topics that we plan to cover:

1) Brief Review of class field theory (both local and global),
2) Basic notions and examples of Galois representations,
3) Galois representations attached to elliptic curves and modular forms,
4) Galois representations of local Galois groups I: \ell \neq p case
5) Galois representations of local Galois groups II: Introduction to p-adic Hodge theory (\ell = p case)
6) Introduction to deformation theory of Galois representations

Shaunak Vilas Deo

Pre-requistes : Representation Theory of Finite groups (MA 220), Algebraic Number Theory (MA 313), Introduction to Modular Forms (MA 215), Elliptic Curves (MA 353), Class Field Theory

References : 1) J.-P. Serre, Abelian \ell-adic representations and elliptic curves, W. A. Benjamin, Inc., New York-Amsterdam, 1968.
2) J.-P. Serre, Galois cohomology, Springer Monographs in Mathematics, 1997
3) F. Q. Gouvea, Deformations of Galois representations, Arithmetic algebraic geometry (Park City, UT 1999), IAS/Park City Mathematics

MA 379 (AUG) 3 : 0

Linear Algebraic Groups

Syllabus: Basic notions of linear algebraic groups (connected components, orbits, Jordan decomposition), Lie algebras, algebraic tori, solvable and unipotent groups, parabolic and Borel subgroups, representations of linear algebraic groups, reductive and semi-simple groups, the Weyl group, root systems and root datum, classification of connected reductive groups over an algebraically closed field.

Radhika Ganapathy

Pre-requistes :
1. Commutative algebra
2. Some familiarity with basic algebraic

References : 1. T. A. Springer, Linear Algebraic Groups, Modern Birkhaeuser Classics, 2nd edition, 1998.
2. Armand Borel, Linear Algebraic Groups, GTM 126, 2nd edition, 1991.
3. James Humphreys, Linear Algebraic Groups, GTM 21, 1975.

MA 389A (AUG) 1 : 0

Seminar on topics in mathematics I

The students must commit to attending a seminar series (algebra, eigenfunctions, etc) of their choice and attend all the talks during the semester.

Vamsi Pritham Pingali

Pre-requistes : None

References : No references.

Physics

Preface

HE 215 (AUG) 3 : 0

Nuclear and Particle Physics

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

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

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.

Prasad Satish Hegde

Pre-requistes : None

References :

PH 203 (AUG) 3 : 0

Quantum Mechanics-I

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

Sudhir Kumar Vempati

Pre-requistes : None

References : None

PH 205 (AUG) 3 : 0

Math Methods of Physics

Aninda Sinha

Pre-requistes : None

References :

Linear vector spaces, linear operators and matrices, systems of

PH 211 (AUG) 0 : 3

General Physics Laboratory

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

Chandni U , Tapajyoti Das Gupta

Pre-requistes : None

References : None

PH 213 (AUG) 0 : 4

Advanced Experiments in Condensed Matter Physics

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

Anil Kumar P S

Pre-requistes : None

References : None

PH 215 (AUG) 3 : 0

Nuclear and Particle Physics

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

Jyothsna Rani Komaragiri

Pre-requistes : None

References : None

PH 217 (AUG) 3 : 0

Fundamentals of Astrophysics

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

Nirupam Roy

Pre-requistes : None

References : None

PH 231 (AUG) 0 : 1

Workshop practice

Use of lathe, milling machine, drilling machine, and elementary carpentry.Working with metals such as brass, aluminium and steel

Akshay Singh

Pre-requistes : None

References : None

PH 300 (AUG) 1 : 0

Seminar Course

Suja Elizabeth

Pre-requistes : None

References : None

PH 322 (AUG) 3 : 0

Molecular Simulation

Introduction to molecular dynamics, various schemes for integration, inter-and intra-molecular forces, introduction to various force fields, methods for partial atomic charges, various ensembles(NVE, NVT, NPT, NPH), hard sphere simulations, water imulations, computing long-range interactions. Various schemes for minimization: conjugate radient, steepest descents. Monte Carlo simulations, the Ising model, various sampling methods, particle-based MC simulations, biased Monte Carlo. Density functional theory, free energy calculations, umbrella sampling, smart Monte Carlo, liquid crystal simulations, introduction to biomolecule simulations

Prabal Kumar Maiti

Pre-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.

Sumilan Banerjee

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.

Suja Elizabeth

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 362 (AUG) 2 : 0

Radiative Processess in Astrophysics

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

Nirupam Roy

Pre-requistes : None

References : None

PH 363 (AUG) 2 : 0

Introduction to Fluid Mechanics and Plasma Physics

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

Nirupam Roy

Pre-requistes : None

References : None

PH 320 (AUG) 3 : 0

Condensed Matter Physics II

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

Tanmoy Das

Pre-requistes : None

References : None

PH 379 (AUG) 3 : 0

Discrete Photonics and Quantum Analogies

Introduction, Maxwell's equation; Guided wave structures, scalar-paraxial approximation, analogy with Schrödinger equation; Photon statistics, classical and non-classical light; Waveguide modes; Evanescent coupling, coupled two-level system, coupled mode (tight binding) theory; Periodic structures: one-dimensional and two-dimensional, discrete diffraction, photonic band theory, gratings, optical Bloch oscillations; Periodically modulated structures: Floquet theory, effective Hamiltonian, quasi-energy spectrum; Optical pulse propagation, Kerr effect, nonlinear Schrödinger equation, self-phase modulation, solitons; Methods of creating waveguides; Recent development

Sebabrata Mukherjee

Pre-requistes :

Basic understanding of electromagnetic theory, quantum mechanics

References :

1. A W Snyder and J Love, "Optical Waveguide Theory," Springer Science & Business Media
2. A Ghatak and K Thyagarajan, "Introduction to Fibre Optics," Cambridge University Press
3. D J Griffiths, “Introduction to Quantum Mechanics,” Pearson Prentice Hall

PH 375 (AUG) 3 : 0

Symmetry, Topology, and Entanglement in Condensed Matter

Group theory and group representations with applications to the quantum field theory of condensed matter systems. Linear and projective representations. Application to fermionic systems and the tenfold way. Homotopy groups and applications in condensed matter. Topological terms in nonlinear sigma models. Application to spin systems, Dirac fermion systems (such as graphene) and disordered fermionic systems. Entanglement and its characterization. Area law. Short-range entangled phases of matter, including topological insulators. Entanglement in gapless phases. Long-range entangled phases with introduction of topological order. Applications to the quantum Hall effect.
Critical phenomena. Conformal symmetry and conformal field theory. Entanglement structure of quantum field theories.
Topological quantum field theory. Chern-Simons theories. Anyons: Abelian and Non-Abelian. Examples from fractional Hall effect and other topologically ordered phases. Ideas of topological quantum computation. A survey of recent developments in the classification of phases.

Vijay B Shenoy

Pre-requistes :
Advanced Condensed Matter, Quantum Statistical Field Theory

References :
A. Zee, Group Theory in a Nutshell, Princeton University Press, 2016.
M. Nakahara, Geometry, Topology and Physics, CRC Press, 2003.

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.

Apoorva Patel

Pre-requistes : None

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

QT 201 (AUG) 1 : 0

Survey of Quantum Technologies

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

Baladitya Suri

Pre-requistes :
None

References :
Online talks.

QT 209 (AUG) 3 : 0

Introduction to Quantum Communications and Cryptography

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

Apoorva Patel , Varun Raghunathan , Asha Bhardwaj

Pre-requistes : None

References :

Nielsen M.A. and Chuang I.L., Quantum Computation and

QT 203 (AUG) 3 : 0

Physics and Engineering Foundations for Quantum Te

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

Baladitya Suri

Pre-requistes :
None

References :
Online talks.
J J Sakurai -- Modern Quantum Mechanics (any edition)

Mathematical Science_Int PhD

Preface