Preface

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

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

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

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

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

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

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

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

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

1st January 2022

Vijay Natarajan

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

E1 219o (AUG) 3 : 0

Linear Algebra

Pre-requistes : None

References : None

E0 270o (JAN) 3 : 1

Machine Learning

Ambedkar Dukkipati

Pre-requistes : None

References : None

E1 251o (JAN) 3 : 0

Linear and Non-linear Optimization

Chandramani Kishore Singh

Pre-requistes : None

References : None

E9 241o (AUG) 3 : 1

Digital Image Processing

Pre-requistes : None

References : None

E0 251o (JAN) 3 : 1

Data Structures and Graph Analytics

Chandramani Kishore Singh

Pre-requistes : None

References : None

E0 259o (MAY) 3 : 1

Data Analytics

Pre-requistes : None

References : None

CP 214o (AUG) 3 : 1

Foundations of Robotics

This graduate course will serve as an introductory robotics course for students with little/no background in mechanical systems. The course will first build the necessary mathematical framework in which to understand topics such as 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, rigid body transformations, forward and inverse kinematics, forward and inverse dynamics, state space representations. Towards the end of the course advanced topics such as rigid body collisions, and hybrid dynamical systems will also be covered.

Pre-requistes :
None

References : Recommended Texts (these will help greatly with the course content):

Ruina, Andy and Pratap, Rudra,

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

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.

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

DS 265o (AUG) 3 : 1

Deep Learning for Visual Analytics

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

Pre-requistes :
Basics knowledge of Machine learning and Image processing.

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

2. Recent Research papers.

DA 202o (AUG) 3 : 1

Introduction to Data Science

Pre-requistes : None

References : None

DA 231o (AUG) 3 : 1

Data Engineering at Scale

Pre-requistes : None

References : None

DA 203o (JAN) 3 : 1

Introduction to Computing for AI & Machine Learning

Sashikumaar Ganesan

Pre-requistes : None

References : None

DA 212o (MAY) 3 : 1

MLOps at Scale

Pre-requistes : None

References : None

DA 226o (AUG) 3 : 1

Financial Analytics

Pre-requistes : None

References : None

DA 227o (AUG) 3 : 1

Data Mining

Pre-requistes : None

References : None

DA 225o (MAY) 3 : 1

Deep Learning

Pre-requistes : None

References : None

DS 261o (JAN) 3 : 1

Artificial Intelligence for Medical Image Analysis

Phaneendra Kumar Yalavarthy

Pre-requistes : None

References : None

DA 218o (JAN) 3 : 1

Probabilistic Machine Learning: Theory and Applica

Punit Rathore

Pre-requistes : None

References : None

E2 202o (AUG) 3 : 1

Random Process

Pre-requistes : None

References : None

E2 201o (JAN) 3 : 1

Digital Communications

Neelesh B Mehta

Pre-requistes : None

References : None

E2 251o (MAY) 3 : 1

Communication Systems Design

Pre-requistes : None

References : None

E8 242o (AUG) 3 : 1

Radio Frequency Integrated Circuits and Systems

Pre-requistes : None

References : None

E8 204o (JAN) 3 : 1

Antenna Theory and Practice

Debdeep Sarkar

Pre-requistes : None

References : None

E2 287o (JAN) 1 : 1

Communication Networking Lab

Parimal Parag

Pre-requistes : None

References : None

E3 280o (JAN) 3 : 1

Semiconductor devices for nanoelectronics

Kausik Majumdar

Pre-requistes : None

References : None

E1 245o (JAN) 3 : 1

Statistical Inference for Engineers and Data Scientists

Sundeep Prabhakar Chepuri

Pre-requistes : None

References : None

Artificial Intelligence Stream

Preface

E1 219o (AUG) 3 : 0

Linear Algebra

Pre-requistes : None

References : None

E0 270o (JAN) 3 : 1

Machine Learning

Ambedkar Dukkipati

Pre-requistes : None

References : None

E1 251o (JAN) 3 : 0

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Chandramani Kishore Singh

Pre-requistes : None

References : None

E9 241o (AUG) 3 : 1

Digital Image Processing

Pre-requistes : None

References : None

E0 251o (JAN) 3 : 1

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Chandramani Kishore Singh

Pre-requistes : None

References : None

E0 259o (MAY) 3 : 1

Data Analytics

Pre-requistes : None

References : None

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E1 277o (AUG) 3 : 1

Reinforcement Learning

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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

DS 265o (AUG) 3 : 1

Deep Learning for Visual Analytics

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

Pre-requistes :
Basics knowledge of Machine learning and Image processing.

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

2. Recent Research papers.

Data Science & Business Analytics Stream

Preface

DA 202o (AUG) 3 : 1

Introduction to Data Science

Pre-requistes : None

References : None

DA 231o (AUG) 3 : 1

Data Engineering at Scale

Pre-requistes : None

References : None

DA 203o (JAN) 3 : 1

Introduction to Computing for AI & Machine Learning

Sashikumaar Ganesan

Pre-requistes : None

References : None

DA 212o (MAY) 3 : 1

MLOps at Scale

Pre-requistes : None

References : None

DA 226o (AUG) 3 : 1

Financial Analytics

Pre-requistes : None

References : None

DA 227o (AUG) 3 : 1

Data Mining

Pre-requistes : None

References : None

DA 225o (MAY) 3 : 1

Deep Learning

Pre-requistes : None

References : None

DS 261o (JAN) 3 : 1

Artificial Intelligence for Medical Image Analysis

Phaneendra Kumar Yalavarthy

Pre-requistes : None

References : None

DA 218o (JAN) 3 : 1

Probabilistic Machine Learning: Theory and Applica

Punit Rathore

Pre-requistes : None

References : None

Electronics & Communication Engg. Stream

Preface

E2 202o (AUG) 3 : 1

Random Process

Pre-requistes : None

References : None

E2 201o (JAN) 3 : 1

Digital Communications

Neelesh B Mehta

Pre-requistes : None

References : None

E2 251o (MAY) 3 : 1

Communication Systems Design

Pre-requistes : None

References : None

E8 242o (AUG) 3 : 1

Radio Frequency Integrated Circuits and Systems

Pre-requistes : None

References : None

E8 204o (JAN) 3 : 1

Antenna Theory and Practice

Debdeep Sarkar

Pre-requistes : None

References : None

E2 287o (JAN) 1 : 1

Communication Networking Lab

Parimal Parag

Pre-requistes : None

References : None

E3 280o (JAN) 3 : 1

Semiconductor devices for nanoelectronics

Kausik Majumdar

Pre-requistes : None

References : None

E1 245o (JAN) 3 : 1

Statistical Inference for Engineers and Data Scientists

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 250 (JAN) 2 : 0

This Division includes the Department of Biochemistry, Centre for

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

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.

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.

Pre-requistes : None

References : None

BC 205 (JAN) 2 : 0

Fundamentals of Physiology and Medicine

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

Sandeep M Eswarappa

Pre-requistes : None

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

BC 206 (AUG) 2 : 0

Essentials in Immunology

Pre-requistes : None

References **:**

BC 207 (JAN) 2 : 0

Proteomics in Practice

Utpal Tatu

Pre-requistes : None

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

BC 210 (JAN) 3 : 0

Molecular Basis of Ageing and Regeneration

Model systems for studying Ageing and Regeneration (such as Planaria, Hydra,Salamander); Role of cellular processes such as transcription, translation,posttranslational modifications; Signalling mechanisms; Cellular Senescence;Genetic basis of Ageing and longevity; Ageing and Diseases; Organ Senescence ; Obesity / Diabetes / Cardiovascular diseases/Muscle degeneration; Interventions to delay ageing and/or enhance life span.

Varsha Singh , Purusharth Rajyaguru , Nagalingam Ravi Sundaresan

Pre-requistes : None

References :
Principles of Regenerative Biology by Bruce Carlson.,Regeneration Developmental Biology by Scott F Gilbert (6th

BC 302 (JAN) 3 : 0

Current Trends in Drug Discovery

Introduction to the process of Drug discovery, Principles of drug action,Biochemical pharmacology, drug absorption, distribution, metabolism and elimination, bioavailability. Drug receptors and their interactions, dose-response relationships, pharmacokinetics & pharmacodynamics. Use of genomics and proteomics for understanding diseases at the molecular level. Brief introduction to Systems biology, Strategies for target discovery, high throughput screening using genomics, proteomics and bioinformatics for target and lead dentification. Molecular recognition, drug and target structures and chemoinformatics. Druggability, protein-ligand interactions, structure- based ligand design. Lead Identification, Lead optimization and design, Binding site characterization, docking and clustering. Pharmacophore- based approaches, QSAR. Pharmacogenomics & Variability in Drug Response, biochemical mechanisms of drug resistance, examples from current literature

Nagasuma R Chandra

Pre-requistes : None

References : Basic Principles of Drug Discovery and Development by Benjamin E Blass 2015,Structure Based Drug Discovery - An Overview by Roderick E. Hubbard (RSC Publication) 2006,Molecular Pharmacology from DNA to Drug Discovery by John Dickenson,Fiona Freeman,Chris Lloyd Mills

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.

Pre-requistes : None

References : None

Ecological Sciences

Preface

EC 201 (JAN) 2 : 1

Theoretical and Mathematical Ecology

Basic elements of theoretical ecology, building and analyzing mathematical models of ecological systems, generating new ecological insights and hypotheses. Discrete and continuous population models; nonlinear dynamics and bifurcations in ecological models; incorporating stochasticity and space;random walks in ecology and evolution; game theory and ESS; Price equation and levels of selection.

Vishwesha Guttal

Pre-requistes : None

References : None

EC 204 (JAN) 2 : 1

Evolutionary Biology

This course offers an in-depth, hands-on look at the basic principles of evolutionary biology, and discusses the recent advancements and the major ideas in the field. The course has a special emphasis on phylogenetics,population genetics, molecular evolution, genome evolution, and offers exposure to a wide range of theoretical and practical aspects for understanding the micro- and macroevolutionary processes that shape the diversity of life on earth.

Praveen Karanth K

Pre-requistes : None

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

EC 301 (AUG) 2 : 1

Animal Behaviour : Mechanisms and Evolution

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

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

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.

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 306 (JAN) 2 : 1

Advanced ecological statistics

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

Kavita Isvaran

Pre-requistes : None

References : None

EC 101 (AUG) 1 : 0

Process of Scientific Thinking

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

Pre-requistes : None

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

EC 202 (AUG) 2 : 1

Ecology: Pattern and Process

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

Pre-requistes : None

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

EC 206 (JAN) 2 : 1

Evolutionary Genetics

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

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

Kartik Sunagar

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

References : 1. Evolutionary biology. Douglas J. Futuyma (1998). 3rd Sinauer Associates Inc, Publishers, Sunderland.

2. Evolutionary Analysis, Fifth Edition by Jon Herron Scott Freeman.

EC 309A (JAN) 3 : 0

Ecosystems and Global Change

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

Sumanta Bagchi

Pre-requistes :
No specific pre-requisites

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

Neuroscience

Preface

NS 201 (AUG) 2 : 0

Systems Neuroscience

Neuronal biophysics, sensation & perception, motor systems

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.

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.

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.

Pre-requistes : None

References : None

NS 211 (JAN) 3 : 0

Optical Spectroscopy and Microscopy

Transition probabilities; Time dependent perturbation theory; Interaction with strong fields, Second Quantization; Origin of Spontaneous emission;characteristics of stimulated emission; Absorption and emission. Emergence of biophysical methods such as CD, Fluorescence spectroscopy, Energy transfer and other such methods from the above principles. Non-linear optics ; Lasers;Pulsed and CW lasers; Multi photon excitation; optical microscopy; diffraction limit; principles of laser scanning microscopes; photo detection; optical microscope in bits and pieces.

Balaji J

Pre-requistes : None

References : None

NS 301 (JAN) 2 : 0

Topics in Systems and Cognitive Neuroscience

Critical readings and grant writing on various topics in systems neuroscience.

Aditya Murthy , Sridharan Devarajan , Srikanth Padmala

Pre-requistes : None

References : None

NS 302 (JAN) 2 : 0

Topics in Molecular and Cellular Neuroscience

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

Balaji J , Deepak Kumaran Nair , Arnab Barik

Pre-requistes : None

References : None

NS 212 (JAN) 2 : 1

Neural Signal Processing

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

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 202 (JAN) 2 : 0

Developmental Genetics

Current Opinion in Genetics and Development/ Cell Biology/ Plant Biology
• Trends in Genetics/ Cell Biology/ Biochemistry
• Principles of Development by Wolpert and co-authors
• Mechanisms in Plant Development by Leyser and Day
• Plant Physiology by Taiz and Zeiger
•Ecological Developmental Biology by Scott Gilbert and David Epel
•R.V. Stanier,E. A. Adelberg and J. L. Ingraham, General Microbiology, Macmillan Press.

Utpal Nath , Samay Ravindra Pande

Pre-requistes : None

References :
Logic and techniques of molecular genetic analysis. Understanding interaction networks using genetics and genomics. Illustrating the

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

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.

Pre-requistes :
David G. Russell and Siamon Gordon,Phagocyte-Pathogen Interactions: Macrophages and the Host Response to Infection,ASM Press,2009.Knipe,D.M.
References :
"Flint SJ, Enquist L, Racaniello V, Rall GF, Skalka AM. Principles of Virology. 4th ed. ASM Press; 2015. ISBN-10: 1555819338 Knipe DM,Howley

MC 207 (AUG) 3 : 0

Molecular 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

Pre-requistes : None

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

MC 208 (AUG) 2 : 0

Principles of Genetic Engineering

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

Pre-requistes : None

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

MC 210 (JAN) 2 : 0

Molecular Oncology

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

Kumaravel Somasundaram , Annapoorni Rangarajan , Sudha Kumari

Pre-requistes : None

References :

Introduction to Cancer Biology: Immortalization,

MC 211 (JAN) 3 : 0

Molecular basis of Ageing and Regeneration

Mechanisms of Ageing and Regeneration; Model systems for studying Ageing and Regeneration; Role of cellular processes such as transcription, translation, posttranslational modifications; Signalling mechanisms; Cellular Senescence;Genetic basis of Ageing and longevity; Ageing and Diseases; Organ Senescence;Obesity/ Diabetes/Cardiovascular diseases/ Muscle degeneration; Interventions to delay ageing and/or enhance life span

Purusharth Rajyaguru , Nagalingam Ravi Sundaresan

Pre-requistes : None

References : Principles of Regenerative Biology by Bruce Carlson. http://www.sciencedirect. com/science/book /9780123694393 2. Regeneration –Developmental Biology by Scott F Gilbert (6th edition) 3. Hand book of the Biology of Aging,Seventh Edition,by Edward J. Masoro, Steven N. Austad,2010 4. Molecular Biology of Aging (Cold Spring Harbor Monograph Series).

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.

Pre-requistes : None

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

MC 205 (AUG) 2 : 0

Pathogen - Host interactions and immune evasion mechanisms

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

Pre-requistes : None

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

MC 214 (JAN) 2 : 0

Basic and Applied Virology

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

Saumitra Das , Shashank Tripathi , Kesavardana Sannula

Pre-requistes : None

References :
(1) Fields Virology, 6th Edition, Edited by David M. Knipe and Peter M. Howley. Philadelphia, PA, USA. Lippincott Williams &Wilkins.~

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.

Pre-requistes : None

References : None

DB 212 (JAN) 0 : 6

Biological Science

Aravind Penmatsa

Pre-requistes : None

References : None

DB 327 (JAN) 0 : 6

Project- III

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

Aravind Penmatsa

Pre-requistes : None

References : None

MC 216 (JAN) 1 : 0

Biological Safety: Principles and practices

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

Amit Singh

Pre-requistes : None

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

MC 215 (JAN) 2 : 0

Lysosomes and Autophagy

Lysosomes: Organelle contents and environment, functions, discovery of lysosomes and classical papers and experiments, cargo trafficking into-out of lysosomes, position, contact and fusion with other organelles and lysoIP. Transcriptional regulation of lysosome biogenesis, spatiotemporal distribution of lysosomes within a cell, lysosome reformation, lysosomal turnover and exocytosis, lysosome as signaling hubs and nutrient sensor, lysosome cell death, dysfunction and associated diseases. Model systems to study lysosome biology and state of the art methods in monitoring lysosomal biology.

Autophagy: Discovery of autophagy and classical papers and experiments. Principles and biogenesis mechanisms, types of autophagy, organelles specific autophagy, cross talk between lysosomes and autophagy, and autophagy modulation in diseases. Model systems to study autophagy, signaling transduction pathways that affect autophagy. State of the art methods in monitoring autophagy flux.

Subba Rao Gangi Setty

Pre-requistes :
None

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

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.

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.

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.

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.

Pre-requistes : None

References : None

MB 207 (JAN) 2 : 0

DNA - Protein interaction, Regulation of gene expression, Nanobiology

Basic concepts on structural basis for macromolecular recognition. Concept ofcharge in macromolecules, specific and non-specific recognition, symmetry in DNA-protein recognition, structural ensembles, co-operativity, specific examples, story of lambda, restriction enzyme recognition, t-RNA synthetase recognition, promoter-RNA polymerase interaction, inducers and repressors,action at a distance. Single molecular paradigm. Methods to follow nanobiology. DNA-protein recognition at the level of single molecules.

Amit Kumar Baidya

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 , S P 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 211 (JAN) 3 : 1

Advanced Methods in Molecular Simulations

Advanced Methods in Molecular Simulations

Anand Srivastava

Pre-requistes : None

References : None

MB 214 (AUG) 3 : 0

Neuronal Physiology and Plasticity

Neuronal and synaptic physiology: exquisite insights from simple systems;history of technical advances: electrophysiology,imaging and computation;history of conceptual advances: excitable membranes, action potentials, ionchannels, oscillations, synapses, behavioral neurophysiology; complexities of the mammalian neuron; dendritic structure; dendritic ion channels; active properties of dendrites; dendritic spikes and backpropagating action potentials; heterogeneity, diversity and degeneracy in the nervous system;hippocampus as an ideal system for assessing learning and memory; synaptic plasticity: short- term plasticity, long-term potentiation and depression;mechanisms underlying synaptic plasticity; intrinsic plasticity; mechanisms underlying intrinsic plasticity;issues in the credit-assignment problem on mechanisms behind learning and memory.

Pre-requistes : None

References : None

MB 303 (JAN) 3 : 0

Elements of Structural Biology

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

Balasubramanian Gopal

Pre-requistes : None

References : None

MB 305 (AUG) 3 : 0

Biomolecular NMR Spectroscopy

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

Pre-requistes : None

References : None

MB 222 (JAN) 3 : 0

Electron microscopy and 3D image processing for Life sciences

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

Somnath Dutta , Vidya Mangala Prasad

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

References : Books and references

1. John J. Bozzola and Lonnie D. Russell (1992). Electron Microscopy (Jones & Bartlett Publishers).
2. Ray F. Egerton (2005). Physical Principles of Electron Microscopy: An Introduction to TEM, SEM, and AEM (Springer).

MB 215 (JAN) 2 : 0

Neuronal Ion Transport in Health and Disease

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

Giriraj Sahu

Pre-requistes :
Basic knowledge about ion channels and cellular neuroscience

References :
1. Ion Channels of Excitable Membranes: Bertil Hille
2. Neurobiology of Brain Disorders: M. Zigmond
3. Ion Channels and Disease: Frances M. Ashcroft

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.

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.

Pre-requistes : None

References : None

RD 206 (JAN) 2 : 0

Molecular Oncology

Introduction to Cancer Biology: Immortalization, transformation, metastasis; Causes of Cancer: initiators and promoters, carcinogens, tumor viruses, sporadic and familial cancer; Genetic alterations in cancer; Molecular mechanisms of carcinogenesis: cell culture and animal models; Cancer as a tissue: angiogenesis, role of stroma; Cancer spread; metastasis; Cancer stem cells; Resistance to therapy; Cell cycle and cancer; Oncogenes; Tumor suppressor genes; Epigenetic regulation; Transformation by RNA and DNA tumor viruses; Mouse models of cancer; high-throughput techniques in cancer biology, Precision medicine, targeted therapy; Immune system and Cancer, Immune cell help in Cancer, Immunotherapy and Cancer, Experimental systems of immune-oncology, effects of metabolism and microbiome, caveats in immunotherapy using cell biological approaches

Annapoorni Rangarajan

Pre-requistes : None

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

RD 209 (JAN) 2 : 0

Molecular basis of ageing and regeneration

Mechanisms of Ageing and Regeneration, Model systems for Regeneration;
Role of cellular process such as transcription, translation,
posttranslational modifications, Signalling mechanisms; neurogenesis,
Cellular senescence; Model systems for studying Ageing; Genetic basis if
Ageing and longevity; Ageing and diseases; immunosenescence and
inflammation, Organ Senescence; Obesity/Diabetes/Cardiovascular diseases/Muscle degeneration;
Interventions to delay ageing and/or enhance life span (caloric restriction)

Varsha Singh , Purusharth Rajyaguru , Nagalingam Ravi Sundaresan

Pre-requistes : None

References :

Principles of Regenerative Biology by Bruce Carlson.,Regeneration

RD 210 (JAN) 2 : 0

Fundamentals of Physiology and Medicine

Introduction to anatomy, histology, evolutionary medicine and clinical examinations, general human embryology, physiological and pathological aspects of cardiovascular system, respiratory system, renal system, alimentary system,Endocrine system.

Ramray Bhat

Pre-requistes : None

References :

Ganong's Medical Physiology, 23rd Edition,Junqueira's Basic

RD 205 (JAN) 2 : 0

Genetics and Genomic Medicine

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

Arun Kumar , Upendra Nongthomba

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.

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.

Pre-requistes : None

References : will be provided

LS 103 (JAN) 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.

Pre-requistes : None

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

LS 208 (JAN) 2 : 0

Physiology and Neurobiology

Physiology: General concepts in histology, embryology and physiology. Cardiovascular physiology: Evolution of circulatory system, heart and vascular system and related diseases. Pulmonary Physiology: Evolution of respiratory mechanisms, lungs, and related diseases. Renal physiology: Evolution of renal system, kidneys, and related diseases. Gastrointestinal physiology: digestion, absorption, fluid balance kidney liver axis. Endocrinology: Hypothalamus, pituitary, thyroid gland, adrenal gland, pancreas. Functions and diseases.

Neurobiology:
A brief history of neuroscience and the neuronal doctrine; cell biology of a neuron; biochemical basis of resting membrane potential and action potential; neuronal connectivity, synaptic transmission and plasticity; sensory and motor systems; learning and memory; cognition; brain disorders.

Sandeep M Eswarappa , Ramray Bhat , Ashesh Dhawale

Pre-requistes : None

References :
1. Principles of Neural Science by Kandel et al (6th Edn)
2.

LS 205 (JAN) 3 : 0

Ecology and Evolution

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

Praveen Karanth K , Sumanta Bagchi

Pre-requistes : None

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

LS 210 (JAN) 0 : 2

Laboratory course in Genetics and Ecology

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

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

Utpal Nath , Upendra Nongthomba , Maria Thaker , Sumanta Bagchi , Kavita Babu , Saravanan Palani

Pre-requistes : None

References : all materials will be provided

LS 204 (AUG) 3 : 0

Biochemistry and Biophysics

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

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

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 206 (JAN) 3 : 0

Developmental Biology and Genetics

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

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

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

Srimonta Gayen , Kavita Babu , Debabrata Laha

Pre-requistes : None

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

LS 203 (AUG) 3 : 0

Microbiology, Virology and Immunology

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

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

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

Pre-requistes : None

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

LS 207 (JAN) 3 : 0

Fundamentals of Molecular Biology

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

Tanweer Hussain , Rajakumari Sonaimuthu

Pre-requistes : None

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

Division of Chemical Sciences

Preface

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

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

CD Integrated Ph D

IP Inorganic and Physical Chemistry

MR Materials Research Centre

OC Organic Chemistry

SS Solid State and Structural Chemistry

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

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

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

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

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

Prof. G. Mugesh

Dean

Division of Chemical Sciences

CD 221 (JAN) 3 : 0

Physical Chemistry II: Statistical Mechanics

Review of thermodynamics, postulates of statistical mechanics, ensembles, classical and quantum statistics. Application to ideal gas, rotational and vibrational problems, black body radiation, electron conduction in metals,specific heats of solids, classical fluids, and phase transitions.

Awadhesh Narayan

Pre-requisites : None

References : E. Fermi, Thermodynamics,H.B. Callen, Thermodynamics and Introduction to Thermostatistics,D.A. MacQuarrie, Statistical Mechanics,D. Chandler, Introduction to Modern Statistical Mechanics

CD 222 (JAN) 3 : 0

Material Chemistry

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

Prabeer Barpanda

Pre-requisites : None

References : A.R. West, Solid State Chemistry and its Applications John Wiley and Sons, 1984.,J.F. Shackelford, Introduction to Materials Science for Engineers,MacMillan, 1988.,....

CD 223 (JAN) 3 : 0

Organic synthesis

Principles of selectivity and reactivity in the use of reagents for oxidation, reduction and bond forming reaction. Planning a synthesis, antithetic analysis, synthons, linear and convergent synthesis.

Akkattu T Biju,Durga Prasada Rao Hari

Pre-requisites : None

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

CD 224 (JAN) 2 : 1

Computers in Chemistry

Basic programming in Python using simple examples. Numerical methods: interpolation, numerical integration and differentiation, Gaussian quadrature,basic linear algebra, eigensolutions, linear and non-linear data fitting,solutions of ODEs.

Sai G Ramesh

Pre-requisites : None

References : Any accessible book on numerical methods.,....,.....

CD 225 (JAN) 0 : 4

Physical and Analytical Chemistry Laboratory

Langmuir adsorption, chemical analysis by potentiometry, conductometry and iodometry methods, pH-metry, cyclic voltammetry, flame photometry,electronic states by uv-visible spectroscopy, IR spectroscopy, solid state chemistry – synthesis of solids and chemical analysis, X-ray diffraction.

Das P K,Shivakumara C,Aninda Jiban Bhattacharyya

Pre-requisites : None

References : (a) Vogel, A.I, Vogel's text book of quantitative chemical analysis Longman 1989., (b) David R Shoemaker, Carl W. Garland and Nibler J.W., Experiments in Physical Chemistry, McGraw-Hill International Edition, 1989., (c) Relevant literature from Chemical Education (ACS Publications) and other pedagogic Chemistry Journals

CD 241 (JAN) 0 : 14

Research Project

Partha Sarathi Mukherjee

Pre-requisites : None

References : None

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

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 214 (AUG) 2 : 1

Crystallography for Chemists

Crystal symmetry. Generation and properties of X-rays.Diffraction theory, reciprocal lattice. Experimental aspects.Rotation, Weissenberg precession and diffractometer techniques. Structure factor equation. Electron density function. Phase problem. Structure solution. Introduction to direct methods. Refinement.Absolute configuration, molecular interactions, solid state reactions. Chemical reaction paths. Electron density studies. Experiments on structure solution related problems. Crystal symmetry. Generation and properties of X-rays. Diffraction theory, reciprocal lattice. Experimental aspects. Rotation, Weissenberg precession and diffractometer techniques. Structure factor equation. Electron density function. Phase problem. Structure solution. Introduction to direct methods. Refinement. Absolute configuration, molecular interactions,solid state reactions. Chemical reaction paths. Electron density studies. Experiments on structure solution related problems.

Pre-requistes : None

References : (1) C. A. Taylor, A nonmathematical introduction to X-ray diffraction. (2) G. Stout and L. H. Jensen, X-ray structures determination. (3) M. J.Buerger, X-ray Crystallography

IP 311 (AUG) 3 : 0

Bio and Medicinal Inorganic Chemistry

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

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

Pre-requistes : None

References :

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

IP 321 (AUG) 2 : 0

Spectroscopy and Astrochemistry

Electromagnetic spectrum, nature, emission and absorption of light, Beer-Lambert Law, rotational, vibrational and rovibrational spectroscopy, electronic spectroscopy. Matter and radiation in the early universe, formation of atoms and molecules, Chemical composition of circumstellar and interstellar objects. Modern techniques of microwave spectroscopy and application to astrochemistry, Buckminsterfullerene, polycyclic aromatic hydrocarbons, interstellar dust and particles. Analytical instruments used on probes and spacecraft, Chemical physics of interfaces, aerosols and its significance for planetary and astro- chemistry.

Pre-requistes : None

References : (1) D. Rehder, Chemistry in Space, Wiley (2010). (2) C. Vallance, Astrochemistry, World Scientific (2017). (3) I. N. Levine, Molecular Spectroscopy. (4) P. Bernath, Spectra of Atoms and Molecules, 3rd Edition; Oxford University Press (2016).

IP 322 (JAN) 3 : 0

Polymer Chemistry

Concepts and terminology. Principles of polymerization – chain versus step growth process. Kinetics of chain polymerization process, estimation of various rate constants. Determination of molecular weight of polymers and their distribution.Solution properties and chain dimension. Characteristics and mechanisms of various chain polymerizations – radical, cationic, anionic,NZiegler-Natta and ring opening metathesis polymerizations.Living polymerizations – criteria for livingness, newer methods for living polymerizations – GTP, ATRP and TEMPO-mediated radical polymerizations. Copolymerization – random, alternating and block copolymers and kinetic schemes for analysis of copolymerization. Micro-structural analysis of polymers by NMR –estimation of regio- and stereo-regularity in polymers,sequence distribution in copolymersetc., and mechanisms for stereo-regulation.

Ramakrishnan S

Pre-requistes : None

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

IP 323 (JAN) 3 : 0

Topics in Basic and Applied Electrochemistry

Electrode kinetics and electrochemical techniques: polarizable and non- polarizable interfaces; current-potential relationship; methods of measurement of kinetic parameters; over potential; symmetry factor and transfer coefficient; mechanistic criteria; diffusion, activation phenomena. Steady state and potential step techniques; polarography; cyclic voltammetry; chrono- methods; convective diffusion systems: rotating disc and ring disc electrodes; microelectrodes; AC impedance techniques - concepts and applications. Applied topics: fundamentals of batteries: primary, secondary, reserve batteries; solid state and molten solvent-batteries; fuel cells. Photo-electrochemical solar cells and conversion of solar energy.Corrosion – fundamentals and applications.

Sampath S , Chinmoy Ranjan

Pre-requistes : None

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

IP 327 (JAN) 3 : 0

Chemical Dynamics

[1] Phenomenology and Experiments: Elastic, Inelastic and reactive scattering; Potential Scattering; Newton Diagrams; Experiments; Physical Observables; Differential and total cross sections; Angular Distribution - Forward and Backward Scattering. [2] Potential Energy Surfaces: Diabatic and adiabatic representations - Born-Oppenheimer Approximation; Contour Diagrams; Reaction Dynamics as a Probe for Potential Energy Surfaces; Simple Classical Trajectory Calculations. [3] Transition from macroscopic to microscopic kinetics; thermal and energy dependent rate constants, k(T) and k(E); Dynamics of bimolecular collisions; simple collision model; Transition state theory (TST); variational TST; Roaming reactions and reactions with higher order saddle points. [4] Unimolecular reaction dynamics; Lindeman-Hinshelwood mechanism; Rice-Ramsperger-Kassel-Marcus (RRKM) theory; Statistical adiabatic channel model. [5] Experimental determinations of kinetic parameters: molecular beam scattering, state-resolved spectroscopic techniques.

Das P K , Arunan E

Pre-requistes : None

References : 1. R. B. Bernstein and R. D. Levine, Molecular Reaction Dynamics and Chemical Reactivity, Oxford University Press (1987).
2. R. B. Bernstein, Chemical Dynamics via Molecular Beam and Laser Techniques, Oxford University Press (1985).
3. N. F. Mott and H. S. W. Massey, The Theory of Atomic Collisions, First, Second or Third Edition, Oxford University Press (1965).

Materials Research Centre

Preface

MR 222 (JAN) 3 : 0

Chemistry of Materials

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

Prabeer Barpanda

Pre-requistes : None

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

MR 306 (JAN) 3 : 0

Electron Microscopy in Materials Characterization

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

Ravishankar Narayanan

Pre-requistes : None

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

MR 308 (JAN) 2 : 1

Computational Modeling of Materials

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

Abhishek Kumar Singh

Pre-requistes : None

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

MR 309 (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.

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.

Organic Chemistry

Preface

OC 203 (AUG) 3 : 0

Organic Chemistry I

Pre-requistes : None

References : None

OC 231 (AUG) 3 : 0

Chemistry of Proteins and Peptides

Amino acids, peptide synthesis, geometry and oligopeptide conformations. Non-covalent interactions, dynamism in peptides, molecular recognition, Ramachandran plot, Foldamers. Protein architecture, protein-protein interactions, protein stability. Peptide conformational analysis. Protein solubility, pKa, protein aggregates, isofolding, unfolded proteins, membrane proteins. Peptidomimetics, isosteres, folding peptides. Enzymes: mechanisms of selected enzymes, enzyme inhibitors. Important developments in current literature.

Pre-requistes : None

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

OC 234 (JAN) 3 : 0

Organic synthesis

Principles of selectivity and reactivity in the use of reagents for oxidation,reduction and bond forming reaction. Planning a synthesis, antithetic analysis, synthons, linear and convergent synthesis

Akkattu T Biju , Durga Prasada Rao Hari

Pre-requistes : None

References : Warren S.,Designing Organic Synthesis,1978,Carruthers W. S.,Some Modern Methods of Organic Synthesis 3rd edition

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.

Pre-requistes : None

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

OC 303 (AUG) 3 : 0

Carbohydrate Chemistry

Structures and conformational itineraries of monosaccharides;Reactions of monosaccharides: reactivity profiles at each carbon center; ring expansions and contractions; reactions at anomeric carbon and epimeric carbons; deoxy sugars; anhydrosugars; protecting group methods; chemical and enzymatic glycosylations to oligosaccharides;glycosidic bond stabilities; naturally-occurring oligo- and polysaccharides and their conformations; chiral auxiliaries and modifications of sugars to carbocycles and heterocycles; aspects of animal and plant olysaccharides, glycoproteins, proteoglycans and glycosaminoglycans; selected natural product synthesis originating from a sugar scaffold.

Pre-requistes : None

References :
Monosaccharides: Their chemistry and their roles in natural products,P. Collins and R. Ferrier,John Wiley & Sons Ltd.,Chichester,1998.

OC 304 (JAN) 3 : 0

Physical Methods of Structure Elucidation

Structural elucidation of organic compounds using physical methods. Principles underlying the following techniques and their applications in organic chemistry will be discussed:Infrared, NMR (1H and 13C) Spectroscopy, and MassSpectrometry; Circular dichroism, 2D NMR spectroscopy Other physical methods like.

Jayaraman N

Pre-requistes : None

References : Stothers,J.B. Carbon-13 NMR spectroscopy,Vol.XXIV,Academic Press,1972

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.

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.

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.

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.

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.

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

Pre-requistes : None

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

CY 226 (JAN) 0 : 3

Advanced Laboratory - II

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

Shivakumara C , Aninda Jiban Bhattacharyya

Pre-requistes : None

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

CY 224 (JAN) 3 : 0

Chemistry of Biomolecules

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

Mrinmoy De

Pre-requistes : None

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

CY 225 (JAN) 3 : 0

Spectroscopic Methods for Structure Determination

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

Uday Maitra , Jayaraman N

Pre-requistes : None

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

CY 303 (JAN) 3 : 0

Inorganic Chemistry-2: Organometallic Chemistry

Structure and bonding in organometallic compounds – isolobal analogies, metal carbonyls, carbenes and NHC complexes, olefin and acetylene complexes, alkyls and allyl complexes, metallocenes. Major reaction types – oxidative addition, reductive elimination, insertion, isomerization and rearrangement reactions. Catalytic reactions: metathesis, hydrogenation, allylic activation, C-C coupling reactions, C-X coupling.

Balaji R Jagirdar

Pre-requistes : None

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

Division of EECS

Preface

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

E0 Computer Science and Engineering

E1 Intelligent Systems and Automation

E2 Communication Systems

E3 Electronic Devices, Circuits and Technology

E4 Power and Energy Systems

E5 High Voltage and Insulation Engineering

E6 Power Electronics and Drives

E7 Photonic Devices, Circuits and Systems

E8 Electromagnetic, Microwaves and Antennas

E9 Signal Processing, Acoustics and Bioengineering

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

M Tech in Electrical Engineering (EE)

M Tech in Communication and Networks (ECE)

M Tech in Computer Science and Engineering (CSA)

M Tech in Electronics Systems Engineering (ESE)

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

M Tech in Signal Processing (EE and ECE)

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

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

Prof. Rajesh Sundaresan

Dean

Division of EECS

Computer Science and Automation

Preface

E0 238 (JAN) 3 : 1

Intelligent Agents

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

Susheela Devi V

Pre-requistes : None

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

E0 220 (JAN) 3 : 1

Graph Theory

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

Sunil Chandran L

Pre-requistes : None

References : None

E0 224 (AUG) 3 : 1

Computational Complexity Theory

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

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.

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.

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.

Pre-requistes : None

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

E0 232 (AUG) 3 : 1

Probability and statistics

Pre-requistes : None

References : None

E0 234 (JAN) 3 : 1

Introduction to Randomized Algorithms

Arindam Khan

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.

Pre-requistes : None

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

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.

Pre-requistes : None

References : None

E0 248 (JAN) 3 : 1

Theoretical Foundations of Cryptography

This course is a complexity-theoretic introduction to Cryptography. Emphasis will be placed on exploring connections between various fundamental cryptographic primitives via reductions. Some of the primitives we will cover are one-way functions, pseudo-random generators, pseudo-random functions,trapdoor permutations, encryption, digital signatures, hash functions, commitments. We will also try to cover some special topics (private information retrieval, zero-knowledge proofs, oblivious transfer etc.).

Bhavana Kanukurthi

Pre-requistes : None

References : None

E0 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.

Pre-requistes : None

References :

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

E0 253 (JAN) 3 : 1

Operating Systems

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

Vinod Ganapathy

Pre-requistes : None

References : None

E0 255 (JAN) 3 : 1

Compiler Design

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

Uday Kumar Reddy B

Pre-requistes : None

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

E0 256 (AUG) 3 : 1

Theory and Practice of Computer Systems Security

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

Pre-requistes : None

References : None

E0 270 (JAN) 3 : 1

Machine Learning

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

Ambedkar Dukkipati

Pre-requistes : None

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

E0 271 (AUG) 3 : 1

Graphics and Visualization

Graphics pipeline; transformations; viewing; lighting and shading; texture mapping; modeling; geometry processing - meshing, multi- resolution methods,geometric data structures; visualization - visualization pipeline, data reconstruction, isosurfaces,volume rendering, flow visualization.

Pre-requistes : None

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

E0 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.

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.

Pre-requistes : None

References : None

E0 343 (JAN) 3 : 1

Topics in Computer Architecture

Govindarajan R

Pre-requistes : None

References : None

E0 358 (AUG) 3 : 1

Advanced Techniques in Compilation and Programming for Parallel Architectures

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

Pre-requistes : None

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

E0 399 (MAY) 1 : 2

Research in Computer Science

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

Pre-requistes : None

References :

E1 254 (JAN) 3 : 1

Game Theory

Introduction: rationality, intelligence, common knowledge, von Neumann - Morgenstern utilities; Noncooperative Game Theory: strategic form games, dominant strategy equilibria, pure strategy nash equilibrium, mixed strategy Nash equilibrium, existence of Nash equilibrium, computation of Nash equilibrium, matrix games, minimax theorem, extensive form games, subgame perfect equilibrium, games with incomplete information,Bayesian games.Mechanism Design:Social choice functions and properties, incentive compatibility, revelation theorem, Gibbard-Satterthwaite Theorem, Arrow's impossibility theorem, Vickrey- Clarke-Groves mechanisms, dAGVA mechanisms,Revenue equivalence theorem, optimal auctions. Cooperative Game Theory:Correlated equilibrium, two person bargaining problem, coalitional games, The core, The Shapley value, other solution concepts in cooperative game theory. References: Roger B. Myerson, Game Theory: Analysis of Conflict, Harvard University Press, September 1997.

Narahari Y , Siddharth Barman

Pre-requistes : None

References : None

E1 277 (JAN) 3 : 1

Reinforcement Learning

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

Shalabh Bhatnagar

Pre-requistes : None

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

E1 396 (AUG) 3 : 1

Topics in Stochastic Approximation Algorithms

Pre-requistes : None

References : None

E0 205 (JAN) 3 : 1

Mathematical Logic and Theorem Proving

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

Deepak D'Souza

Pre-requistes : None

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

E0 208 (JAN) 3 : 1

Computational Geometry

Motivation and objective of the course: Computational Geometry is an area of computer science that looks at the computational aspects of geometric problems such as running time of an algorithm, space occupied by a data structure, design of polynomial time approximation algorithms.This area has been well studied over thelast four decades and has found applications in computer graphics, computer- aided design, geographic information systems, robotics, etc. This course will focus on the theoretical aspects of algorithms and data structures for various geometric problems. Syllabus: The list of topics covered in this course include a. Convex hulls: 2-D and higher dimensional convex hulls, output sensitive algorithms, randomized incremental construction b. Intersection detection: Segment intersection, plane sweep technique. c.Geometric data structures for range searching and point location: Segment and interval trees, range trees, kd-tree, persistence. d. Proximity problems:Voronoi di

Sathish Govindarajan , Rahul Saladi

Pre-requistes : None

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

E0 314 (JAN) 3 : 1

Proof Systems in Cryptography

The course is intended to introduce cryptographic proof systems and applications to students studying cryptography. Syllabus: The tentative topics that will be covered: *Interactive proofs: Class IP, IP=PSPACE Sumcheck protocol, doubly efficient proofs Delegating computation, interactive proofs for muggles Zero-knowledge (ZK) proofs * Foundations of ZK: ZK for NP,motivation and definitions Round complexity, Non-black-box Zero-knowledge Sequential and Parallel composition Limitations and lower bounds, Witness indistinguishability * More ZK: Honest verifier zero-knowledge Malicious verifier zero- knowledge, proof of knowledge, zero-knowledge arguments Sigma protocols, Non-interactive ZK, Groth-Sahai proof system MPC and zero-knowledge, MPC-in-the head * SNARKs (Succinct Non-interactive ARguments of Knowledge):PCP, Succinct arguments, separation from falsifiable assumptions Preprocessing SNARKs with trusted setup SNARKs from linear PCP Polynomial commitments,universal updatable SNAR

Chaya Ganesh

Pre-requistes : None

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

CS 299 (JAN) 0 : 21

M Tech Project CSA

M Tech Project

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.

Pre-requistes :
Reasonable level of previous exposure with Combinatorics/Graph Theory.
The students have consult the instructor to decide.

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

E0 280 (JAN) 3 : 1

Deep Generative Models

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

Chiranjib Bhattacharyya

Pre-requistes :
This course will build on E0270, E1213.

References : Relevant Literature

E0 215 (AUG) 3 : 1

Algorithms Under Uncertainty

In many domains the input arrives over time and an algorithm is required to make its current decision without knowing the future in its entirety. This requirement---of online decision making with uncertain inputs---naturally appears in various real-world settings, such as such as ad allocations and job scheduling. This course will cover multiple algorithmic approaches that have been developed for dealing with such algorithmic problems involving uncertainty. These techniques are quite diverse and span several research areas including (i) competitive analysis of algorithms, (ii) regret minimization and online convex optimization in theoretical machine learning (iii) stochastic approaches such as multi-armed bandits and prophet inequalities.
In this course, we address both classical works and several recent developments in these fields. Another goal of the course will be to understand the strengths and weakness (lower bounds) of various design methodologies.
The following topics will l

Pre-requistes :
E0 225 (Design and Analysis of Algorithms) is a soft prerequisite.

References :
a. Allan Borodin, and Ran El-Yaniv. Online computation and competitive analysis. Cambridge University Press, 2005.

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.

Pre-requistes : None

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

E0 316 (JAN) 3 : 1

Interacting Particle Systems

a. Convergence of Probability Measures: Prohorov Metric and its connections to weak convergence, Prohorov's Theorem, Weak convergence in the space of right continuous function with left limits.
b. Markov Processes: Markov jump and Feller processes, Martingale problem, Martingale problem for interacting particle systems, Convergence theorems for Markov processes. Application: Asymptotic topology of dynamic simplicial complexes.
c. Interacting Particle Systems and Finite Markov Information Exchange Processes: Averaging model, Voter model, Epidemic models and first-passage percolation, SIR and SIS epidemics, contact process
d. Mean field-limit: Processes on the complete graph, Mean-field limit of the Ising model, Analysis of the mean-field model, Functions of Markov processes, Mean-field contact process, Mean-field voter model, Mean field games, and Mean field equilibria
e. Construction and ergodicity: Poisson construction, Generator construction, Ergodicity
f. Recent Literature

Gugan Chandrashekhar Thoppe

Pre-requisites :
Students should have completed a graduate level course on probability.

References : a. Ethier, S.N. and Kurtz, T.G., 2009. Markov processes: characterization and convergence. John Wiley & Sons.
b. Liggett, T.M., 2004. Interacting particle systems-An introduction.
c. Swart, J.M., 2017. A course in interacting particle systems. arXiv preprint arXiv:1703.10007.

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

Govindarajan R , Arkaprava Basu , Sumit Kumar Mandal

Pre-requisites :
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

Electrical Communication Engineering

Preface

E3 238 (AUG) 2 : 1

Analog VLSI Circuits

Review of MOS device characteristics, Long channel MOS, Second order effects, MOS small signal parameters and models, MOS capacitance. Concept of fT,Bipolar transistors, Small signal parameters of BJTs, Common Emitter/Common source Amplifiers, CB/CG Amplifiers Emitter/Source followers, Source Degeneration, Cascodes, emitter/Source coupled pairs, Current Mirrors,Differential Pairs,Frequency Response, Noise, Feedback, Linearity,Operational Amplifiers: Telescopic and Folded Cascode, Stability and Compensation, Slew rate and setting, Common Mode Feedback

Pre-requistes : None

References : Behzad Razavi, Design of Analog CMOS Integrated Circuits~Grey,Hurst, Lewis and Meyer, Analysis and Design of Analog Integrated Circuits~Selected Papers and Patents

E0 259 (AUG) 3 : 1

Data Analytics

This course will be taught jointly by Professors Rajesh Sundaresan and Ramesh Hariharan. Data Analytics is assuming increasing importance in recent times. Several industries are now built around the use of data for decision making. Several research areas too, genomics and neuroscience being notable examples,are increasingly focused on large-scale data generation rather than small-scale experimentation to generate initial hypotheses. This brings about a need for data analytics. This course will develop modern statistical tools and modelling techniques through hands-on data analysis in a variety of application domains. The course will illustrate the principles of hands-on data analytics through several case studies (8-10 such studies). On each topic, we will introduce a scientific question and discuss why it should be addressed. Next, we will present the available data, how it was collected, etc. We will then discuss models, provide analyses, and finally touch upon how to address th

Pre-requistes : None

References : None

E1 244 (JAN) 3 : 0

Detection and Estimation Theory

Hypothesis testing, Neyman-Pearson theorem, likelihood ratio test and generalized likelihood ratio test, uniformly most powerful test,multiple-decision problems, detection of deterministic and random signals in Gaussian noise, detection in non-Gaussian noise, sequential detection, introduction to nonparametric testing. Parameter Estimation: Unbiasedness, consistency, Cramer-Rao bound, sufficient statistics, Rao- Blackwell theorem, best linear unbiased estimation, maximum likelihood estimation. Bayesian estimation: MMSE and MAP estimators, Wiener filter, Kalman filter, Levinson-Durbin and innovation algorithms.

Vaibhav Katewa

Pre-requistes : None

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

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

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.

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,Chernoff bound. 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, continuous time Markov chains,the Poisson process, simple Markovian queues.

Pre-requistes : None

References : B. Hajek, An Exploration of Random Processes for Engineers, Course Notes, 2009,~A. Kumar, Discrete Event Stochastic Processes, Online book.~Geoffrey Grimmett and David Stirzaker, Probability and Random Processes, 3rd edition,2001~Introduction to Probability, Dimitri P.Bertsekas and John N. Tsitsiklis,2nd edition, 2008.

E2 203 (JAN) 3 : 0

Wireless Communication

Wireless channel modeling; diversity techniques to combat fading; cellular communication systems, multiple-access and interference management; capacity of wireless channels; opportunistic communication and multiuser diversity;MIMO – channel modeling, capacity and transmit and receiver architectures;OFDM.

Neelesh B Mehta

Pre-requistes : None

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

E2 204 (JAN) 3 : 0

Stochastic Processes and Queueing Theory

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

Parimal Parag

Pre-requistes : None

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

E2 205 (AUG) 3 : 0

Error-Control Coding

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

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.

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.

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.

Pre-requistes :
Basic linear algebra, probability, and knowledge of a programming language like MATLAB or Python to conduct simple simulation exercises.

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

E2 221 (AUG) 3 : 0

Communication Networks

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

Pre-requistes : None

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

E2 241 (JAN) 3 : 0

Wireless Networks

Macromodels for power attenuation in mobile wireless networks (path loss, shadowing, multipath fading). Link budget analysis. Cellular networks;FDM/TDM/TDMA: spatial reuse, cochannel interference analysis, cell sectoring,channel allocation (fixed and dynamic), handover analysis, Erlang capacity analysis. CDMA: interference analysis, other cell interference, hard and soft handovers, soft capacity, and Erlang capacity analysis; examples from GSM,IS95 and WCDMA networks. OFDMA: simple models for scheduling and resource allocation. Wireless random access networks: ALOHA, CSMA/CA; IEEE 802.11 WLANs and their analysis. Wireless ad hoc networks: links and random topologies,connectivity and capacity, scaling laws, scheduling in ad hoc networks;wireless ad hoc internets and sensor networks.

Utpal Mukherji

Pre-requistes : None

References : A. Kumar, D. Manjunath, and J. Kuri, Wireless Networking, Morgan Kaufman, 2008. ~G. L. Stuber, Principles of Mobile Communications, 2nd edition, Kluwer Academic Publishers, 2001. ~D. Tse and P. Viswanath,Fundamentals of Wireless Communication, Cambridge University Press,2005.

E2 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

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.

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

Pre-requistes : None

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

E7 211 (AUG) 3 : 0

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

Pre-requistes : None

References :
1) C. R. Pollock and M. Lip Son, Integrated Photonics, Kluwer Pub., 2003. 2) T. Tamir, (ed), Guided-wave optoelectronics, (2nd edition),

E7 214 (JAN) 3 : 0

Optoelectronics Devices

This course is intended to be an introduction and bit more in-depth discussion into the field of semiconductor optoelectronics. This would be a good bridge between the microelectronic devices and photonics disciples offered at the Institute. The course would require some basic understanding of semiconductors and calculus at undergraduate level as a pre-requisite. The main topics which would be covered are as follows: Quick refresher into semiconductor physics:band structures, doping, density of states, carrier concentration and p-n junctions. Optical transitions in semiconductors: different radiative and non-radiative processes, and rate calculations. Light emitters: LEDs and Lasers, diode structures, characteristics (LI curves, speed etc.), Lasing condition,hetero-structures, quantum wells, quantum dot lasers and VCSELs. Light detectors: Photodiodes, structure, biasing conditions, photovoltaic and photoconductive devices, solar cells, p-i-n and avalanche photodiodes, characteristics

Varun Raghunathan

Pre-requistes : None

References :
B.E.A. Saleh and M.C. Teich, "Fundamentals of Photonics," Wiley, 2nd edition,ISBN: 978-0-471-35832-9. ~J.M. Liu, "Photonic devices,"

E7 221 (JAN) 2 : 1

Fiber-Optic Communication

Introduction to fiber optics; light propagation. Optical fibers; modes, dispersion, low, nonlinear effects; Optical transmitters: LEDs, Semiconductor Lasers, Transmitter design; Optical receivers: Photodetectors, Receiver design, Noise, sensitivity; System design and performance: voice, video, data transmission, analog and digital systems, standards; Broadband local area optical networks and WDM systems; coherent communication systems; long distance telecommunications using optical amplifiers and solitons. Introduction to topics of current interest: all optical networks, integrated optics, MOEMS; microwave photonics. Experiments on characteristics of optical fibers, sources and detectors, analog and digital link, WDM system, tutorial on optical fiber system design, simulation of optical fiber modes.

Srinivas Talabattula

Pre-requistes : None

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

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++).

Pre-requistes : None

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

E8 242 (JAN) 2 : 1

Radio Frequency Integrated Circuits and Systems

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

Vinoy K J

Pre-requistes : None

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

E9 231 (JAN) 3 : 0

MIMO Signal Processing

In this course, we cover the theory, algorithms, and practical considerations in multiple-antenna adaptive wireless communication systems. The topics covered will include the useful results from information theory, parameter estimation theory, array processing, and wireless communications, all specialized to the case of advanced multiple-antenna adaptive processing. We will also discuss various design issues in ad hoc networks, cognitive radio,and MAC protocols for multiple antenna systems.

Hari K V S

Pre-requistes : None

References : Daniel W. Bliss and Siddhartan Govindasamy, "Adaptive Wireless Communications: MIMO Channels and Networks," Cambridge University Press, 2013.~Xiaodong Wang and Vincent Poor, "Wireless Communication Systems: Advanced Techniques for Signal Reception," Prentice Hall Inc., 2004.

E9 271 (JAN) 3 : 0

Space-Time Signal Processing and Coding

Multiple-Input Multiple-Output (MIMO) communication systems: Space-Time Code construction and decoding algorithms, Distributed space-time coding. Coding and signal processing for multi-way relay systems. Coding and algorithms for broadcast, multicast and interference channels.Simultaneous Wireless Information and Power Transfer (SWIPT) systems. Wireless Network Coding

Sundar Rajan B

Pre-requistes : None

References :
A. Paulraj, R. Nabar and D. Gore. Cambridge University Press, 2003. ~Current literature

E2 242 (JAN) 3 : 0

Multiuser Detection

Direct Sequence spread spectrum, spreading sequences and their correlation functions, near-far effect in DS-CDMA, error probability for DS-CDMA on AWGN channels, Multiuser Detection – MF detector, decorrelating detector, MMSE detector. Successive interference canceller, parallel interference canceller,linear PIC. Performance analysis of multiuser detectors and interference cancellers. Low complexity multiuser detectors for MIMO systems.Multiuser/MIMO detection using belief propagation, probabilistic data association, meta-heuristics, and Markov chain Monte carlo techniques. Spatial modulation index modulation for multiuser systems.

Chockalingam A

Pre-requistes : None

References : S. Verdu, Multiuser Detection, Cambridge Univ.Press, 1998.~A. Chockalingam and B. Sundar Rajan, Large MIMO Systems, Cambridge Univ.Press, February 2014.~H. Wymeersch, Iterative Receiver Design, Cambridge Univ. Press, 2007. ~D. Tse and P. Viswanath, Fundamentals of Wireless Communication, Cambridge University Press, 2005. ~Research Papers in Journals and Conferences

E8 262 (JAN) 3 : 0

CAD for High Speed Chip-Package-Systems

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

Dipanjan Gope

Pre-requistes : None

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

E9 208 (AUG) 3 : 1

Digital Video: Perception and Algorithms

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

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

MV 299 (JAN) 0 : 28

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

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

Arup Polley

Pre-requistes : None

References : None

E8 204 (JAN) 3 : 0

Antenna Theory and Practice

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

Debdeep Sarkar

Pre-requistes : Presence of preliminary knowledge about vectors, coordinate transform, partial differential equations, circuit theory and transmission lines would be great. However, most of these topics will be reviewed before introducing any new topic in the class. Presence of preliminary knowledge about vectors, coordinate transform,

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

E1 260 (JAN) 3 : 1

Optimization for Machine Learning and Data Science

The main goal of this course is cover optimization techniques suitable for problems that frequently appear in the areas of data science, machine learning, communications, and signal processing. This course focusses on the computational, algorithmic, and implementation aspects of such optimization techniques.A subset of the following topics are covered. Convexity, canonical problems, gradient methods, accelerated gradient methods, stochastic gradient descent and variants, Frank-Wolfe, alternating direction method of multipliers, nonconvex and submodular optimization.

Sundeep Prabhakar Chepuri

Pre-requistes : Basic linear algebra, probability, and knowledge of a programming language like MATLAB or Python to conduct simple simulation exercises.

References : 1. A. Beck, First-Order Methods in Optimization, MOS-SIAM Series on Optimization, 2017. 2. S. Bubeck, Convex Optimization: Algorithms and Complexity, Foundations and Trends in Optimization, 2015. 3. F.Bach,“Learning with Submodular Functions: A Convex Optimization Perspective”, Foundations and Trends in Machine Learning, Now Publishers Inc.

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

Pre-requistes :
Preliminary knowledge about circuit design concepts along with electromagnetic theory, transmission lines, waveguides, and radiators

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

Pre-requistes :
Undergraduate level exposure to courses in analog and digital circuits, basic semiconductor device physics and electrical network

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

E2 285 (JAN) 1 : 2

MTech ECE Laboratory Course

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

Sudhan Majhi

Pre-requistes :
None

References : None

EX 299 (JAN) 0 : 28

Project (MTech, Electronics and Communication)

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

Navin Kashyap

Pre-requistes : None

References : Not applicable

E9 333 (JAN) 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 216 (AUG) 3 : 0

Emerging Wireless Communication Technology

Outage probability: Basic of probability distribution function and cumulative distribution function, channel capacity over Rayleigh and Rician channel, outage probability for cooperative communication system
Physical layer security (PLS): Artificial noise based PLS, beamforming based PLS, Secrecy capacity and Secrecy outage probability for MIMO, Transmit and receiver beamforming based PLS
Non-orthogonal multiple access (NOMA): Power domain NOMA, code domain NOMA, sparce code multiple access system, interference cancelation
Intelligent reflecting surface (IRS): IRS system model, MIMO and NOMA based IRS, PLS for IRS, Index modulation for IRS
Full-Duplex (FD): Single carrier based FD, OFDM based FD, MIMO based FD, self-Interference cancelation

Pre-requisites :
Wireless Communication

References : 1.Xiangyun Zhou, Lingyang Song , and Yan Zhang , "Physical Layer Security in Wireless Communications," CRC Press, 1st edition (19 April 2016).
2.Yuanwei Liu, Zhijin Qin, Zhiguo Ding, "Non-Orthogonal Multiple Access for Massive Connectivity," Springer International Publishing

E2 210 (JAN) 3 : 0

Quantum Error-Correcting Codes

This course is intended to serve as an entry into the field of quantum error-correction. The theory is developed from the basics, assuming the postulates of quantum mechanics. No background in quantum mechanics or quantum information processing will be assumed.

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Syllabus:

Basics of quantum computation: qubits, quantum states, quantum gates, measurement, density matrices, trace, partial trace; the no-cloning theorem

Quantum noise models: bit flips and phase flips, depolarizing channel, amplitude damping, phase damping

Quantum error-correction: quantum codes; the Knill-Laflamme conditions; Pauli error basis; discretization of quantum errors

Constructions: Shor's code, CSS codes, stabilizer codes, topological codes (surface codes, color codes), quantum LDPC codes; encoding/decoding circuits

Bounds: quantum Hamming bound, quantum Singleton bound, quantum Gilbert-Varshamov bound

Entanglement-assisted quantum error-correcting codes

Fault-tolerant quantum computation

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Navin Kashyap

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

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

E3 300 (JAN) 3 : 0

Topics in Reinforcement Learning

Overview of Markov Decision Processes, linear systems, ARMAX, linear systems, martingales, concentration results. Reward Biased Maximum Likelihood Estimate (RBMLE) approach to Reinforcement Learning, and its performance analysis. Design and analysis of Reinforcement Learning algorithms for linear systems, system identification.

Rahul Singh

Pre-requistes :
A course on either probability, random processes or measure theory, E2 202 (ECE) or MA-361.

References : Lecture notes given by instructor, material based on several research papers.

Electrical Engineering

Preface

E1 213 (JAN) 3 : 1

Pattern Recognition and Neural Networks

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

Prathosh A.P

Pre-requistes : None

References : None

E1 251 (AUG) 3 : 0

Linear and Nonlinear Optimization

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

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.

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

Pre-requistes : None

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

E9 261 (JAN) 3 : 1

Speech Information Processing

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

Prasanta Kumar Ghosh

Pre-requistes : None

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

E0 246 (JAN) 3 : 1

Real-Time Systems

Hard and soft real-time systems, deadlines and timing constraints, workload parameters, periodic task model, precedence constraints and data dependency,real time scheduling techniques, static and dynamic systems, optimality of EDF and LST algorithms, off-line and on-line scheduling, clock driven scheduling,cyclic executives, scheduling of aperiodic and static jobs, priority driven scheduling, fixed and dynamic priority algorithms, schedulable utilization, RM and DM algorithms, priority scheduling of aperiodic and sporadic jobs, deferrable and sporadic servers, resource access control, priority inversion, priority inheritance and priority ceiling protocols, real-time communication,operating systems. The Laboratory Classes will be conducted using TI C2000 Platform

Rathna G N

Pre-requistes : None

References : References: Jane,Liu W S,Real-Time Systems,Pearson Education,New Delhi

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.

Pre-requistes : None

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

E0 299 (AUG) 3 : 1

Computational Linear Algebra

Theory: Solution of linear equations, vector space,linear transformation,matrix representation, inner-products and norms, orthogonality, least squares,trace and determinant,eigendecomposition, symmetric (Hermitian) matrices and quadratic forms, singular value decomposition, and applications. Computations:Gaussian elimination, iterative methods, QR decomposition,eigenvalues, power method, QR algorithm.

Pre-requistes : None

References : S. Axler, Linear Algebra Done Right, Springer, 2015.~G.Strang, Introduction to Linear Algebra, Wellesley-Cambridge Press,2016.~L. Trefethen and D. Bau,Numerical Linear Algebra, SIAM, 1997.

E1 216 (JAN) 3 : 1

Computer Vision

This course will present a broad, introductory survey intended to develop familiarity with the approaches to modeling and solving problems in computer vision. Mathematical modeling and algorithmic solutions for vision tasks will be emphasised. Image formation: camera geometry, radiometry, colour. Image features: points, lines, edges, contours, texture; Shape: object geometry,stereo, shape from cues; Motion: calibration, registration, multiview geometry, optical flow; approaches to grouping and segmentation; representation and methods for object recognition. Applications;

Srinivasa Venu Madhav Govindu

Pre-requistes : None

References : References: David Forsyth and Jean Ponce , Computer Vision: A Modern Approach,Prentice-Hall India, 2003,Hartley R and Zisserman A, Multiple View Geometry in Computer Vision, Second Edition, Cambridge University Press, 2004.,Current literature

E1 222 (AUG) 3 : 0

Stochastic Models and Applications

Probability spaces, conditional probability, independence,random variables,distribution functions, multiple random variables and joint distributions,moments, characteristic functions and moment generating functions, conditional expectation, sequence of random variables and convergence concepts, law of large numbers, central limit theorem, stochastic processes, Markov chains,Poisson process.

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.

Pre-requistes : None

References : Joao P. Hespanha, “Linear systems theory”, Princeton University Press,2009;Panos J. Antsaklis, Anthony N. Mitchel, "Linear Systems",Birkhauser, 1997;Chi-Tsong Chen, “Linear System Theory and Design”,Oxford University Press;Thomas Kailath, “Linear Systems”, Pearson, 2016 reprint of 1980 edition; Gilbert Strang, “Linear algebra and its applications”

E1 242 (JAN) 3 : 0

Nonlinear systems and control

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

Pavankumar Tallapragada

Pre-requistes : None

References : H. K. Khalil. Nonlinear Systems. Prentice Hall, 3 edition, 2002.~S. S. Sastry. Nonlinear Systems: Analysis, Stability and Control. Number 10 in Interdisciplinary Applied Mathematics. Springer, 1999.~Mathukumalli Vidyasagar. Nonlinear systems analysis. Society for Industrial and Applied Mathematics, 2002.~E. D. Sontag. Mathematical Control Theory: Deterministic Finite Dimensional

E3 252 (JAN) 3 : 1

Embedded System Design for Power Application

Digital Signal Controller (A micro-controller with a DSP engine): Architecture and real time programming in Assembly and Embedded C. Introduction to Fixed Point Arithmetic. Field Programmable Gate Array (FPGA): Architecture and programming of digital circuits including Finite State Machines (FSM) in Verilog HDL. Communication-Chip level: AXI, Board level: SPI, I2C, System level: RS 232, CAN, MODBUS RTU on RS 485. Developing a GUI for supervisory control and monitoring. Introduction to different semiconductor memories: RAM,ROM, NVRAM etc. and their applications. Analog sensing: Anti-aliasing filter design, scaling for fixed point computation, online calibration and biasing. Continuous time feedback controller design and its discrete imeimplementation,D/A and A/D converters, effects of sampling, modeling the Pulse Width Modulator (PWM) etc.Co-design: How to optimally implement an embedded task using a programmable processor (DSC) and a re-configurable hardware (FPGA). Embedded design of a typical Power Conversion System including: process control, protection, monitoring, feedback control etc.

Kaushik Basu

Pre-requistes : None

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

E4 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.

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.

Pre-requistes : None

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

E4 233 (JAN) 3 : 0

Computer Control of Power Systems

Gurunath Gurrala

Pre-requistes : None

References : None

E4 234 (AUG) 3 : 0

Advanced Power Systems Analysis

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

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

E4 238 (JAN) 3 : 0

Advanced Power System Protection

Overview of over-current, directional, distance and differential, out- of-step;protection and fault studies; Service conditions and ratings of relays; Impact of CVT transients on protection; Current Transformer: accuracy classes,dynamic characteristics, impact and detection of saturation, choice for an application; Circuit Breaker: need for breaker failure protection, breaker failure protection schemes, design considerations for breaker failure protection; Transmission line protection: issues and influencing factors,definitions of short, medium and long lines using SIR, protection schemes,fault location identification techniques; Transformer protection: issues,differential protection of auto-transformers, two-winding, three-winding transformers, impact of inrush and over-excitation, application of negative sequence differential, protection issues in 'modern' transformers; Generator protection: issues, generating station arrangements, groundings, protection schemes; Bus protection: issues, bus configurations, protection zones,protection schemes; Overview of HVDC protection systems; Protection scheme for distributed generators (DGs); Special Protection Schemes (SPS); Power system protection testing; Common Format for Transient Data Exchange (COMTRADE), Communication architecture for substation automation; Basics of synchrophasor based Wide Area Monitoring Systems (WAMS);

Sarasij Das

Pre-requistes : None

References : References: Horowitz. S.H. and A.G. Phadke, Power system relaying, by John Wiley & Sons, 3 rd edition 2008.,Mason C.R, The Art and Science of Protective relaying, GE Digital Energy Phadke A.G. and Thorp J.S. Synchronized Phasor Measurements and Their Applications, Springer, 2008,C37 series of IEEE standards on power system protection IEC 61850 - Communication Networks and

E5 201 (JAN) 2 : 1

Production, Measurement,and Application of High Voltage

Generation of HV AC by cascade transformers, resonant circuit, Tesla coil;Generation of HV DC by Cockroft-Walton voltage multipliers; generation of high impulse voltages and currents, Methods of measurement of AC, DC and impulses voltages and currents, basic principles of electric breakdown in gaseous medium; basic aspects of EHV/UHV power transmission, and selected industrial applications of corona. Laboratory: Breakdown experiments on simple air-gaps,Chubb-Fortescue method of AC voltage measurement, Surface discharge demonstration, experiments on insulator strings including pollution flashover, measurement of high impulse voltage, Demonstration of space charge repulsion effect, radio-interference-voltage measurement, Demonstration of Impulse current heating effect.

Rajanikanth B S

Pre-requistes : None

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

E5 206 (AUG) 3 : 0

HV Power Apparatus

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

Pre-requistes : None

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

E5 209 (JAN) 3 : 0

Over voltages in Power Systems

Transient phenomena on transmission lines, methods of analysis and calculation, use of PSPICE, principle of EMTP lightning discharges, origin andcharacteristics of lightning and switching overvoltages, behaviour of apparatus and line insulation under overvoltages. Protection of Apparatus against Overvoltages, Surge arresters, VFTO in GIS, insulation co-ordination.

Satish L

Pre-requistes : None

References : References:,Ragaller K (ed.),Surges in High Voltage Networks,Plenum Press,1980.

E5 212 (JAN) 3 : 0

Computational Methods for Electrostatics

Laplace’s and Poisson’s equations in insulation design, transient fields due to finite conductivity, method of images, images in two-layer soil, numerical methods, finite difference, finite element and charge simulation methods tutorials and demonstration on PC. Programming assignments.

Udaya Kumar

Pre-requistes : None

References : References: Sadiku M N O, Numerical Techniques in Electromagnetics, Second Edn, CRC Press.,Weber E, Electromagnetic Fields, Dover, 1951. Silvester P P and Ferrari R L, Finite Elements for Electrical Engineers, Cambridge University Press, 1996.,Selected journal papers.

E5 213 (AUG) 3 : 0

EHV/UHV Power Transmission Engineering

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.

Pre-requistes : None

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

E6 211 (JAN) 3 : 0

Electric Drives

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

Narayanan G , Samir Hazra

Pre-requistes : None

References : References: Ranganathan V T, Electric Drives, Course Notes, IISc, 2005- 06,Fitzgerald A E , Kingsley C Jr. and Umans S D, Electric Machinery, Tata McGraw Hill, 2003. Leonhard W., Control of Electrical Drives, 3rd Edition, Springer,Miller T J E, Brushless Permanent-Magnet and Reluctance Motor Drives, Oxford Science Publications, 1989 Krishnan R, Permanent-Magnet-Synchronous and

E6 221 (JAN) 3 : 1

Switched Mode Power Conversion

Switched mode power supplies (SMPS): Non-isolated dc-dc converter topologies:continuous conduction mode (CCM) and discontinuous conduction mode (DCM)analysis; non-idealities in the SMPS. Modeling and control of SMPS, duty cycle and current model control, canonical model of the converter under CCM and DCM.Extra element theorem, input filter design. Isolated dc-dc converters: flyback, forward, push-pull, half bridge and full bridge topologies. High frequency output stage in SMPS: voltage doubler and current doubler output rectifiers.Power semiconductor devices for SMPS: static and switching characteristics,power loss evaluation, turn-on and turn-off snubber design. Resonant SMPS:load resonant converters, quasi resonant converters and resonant transition converters. Laboratory exercises on : Opamp circuits for current and voltage sensing in converters, differential amplifiers for sensing in presence of common mode signals, higher order opamp filters, phase shifters, and pulse width modulators, comparator circuits, efficiency modeling and prediction in dc-dc converters, dynamic response and compensator design for dc-dc converters.

Vinod John

Pre-requistes : None

References : References: Robert Ericson, Fundamentals of Power Electronics, Chapman & Hall,2004.,Ramanarayanan V., Switched Mode Power Conversion, 2007 Umanand L, Power Electronics: Essentials and Applications, Wiley India, 2009.,Jayant Baliga B,Power Semiconductor Devices, PWS 1996.

E6 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.

Pre-requistes : None

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

E6 225 (AUG) 3 : 0

Advanced Power Electronics

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

Pre-requistes : None

References : Ned Mohan, Tore M Undeland, William P Robbins, Power Electronics: Converters,Applications and Design, Wiley, Third Edition 2007.,Erickson R W and Maksimovic D, Fundamentals of Power Electronics, Springer, Second Edition 2005.,Umanand L, Power Electronics and Essentials, Wiley, 2009.,Ramanarayanan V,Switched Mode Power Conversion, Course Notes, IISc, 2004. Current

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.

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.

Pre-requistes : None

References : None

E9 246 (JAN) 3 : 1

Advanced Image Processing

Image Features - Harris corner detector, Scale Invariant Feature Transform (SIFT), Speeded Up Robust Features (SURF), edge detection, Hough Transform; Image Enhancement - Noise models, image denoising using linear filters, order statistics based filters and wavelet shrinkage methods, image sharpening, image super-resolution; Image Segmentation - Graph-based techniques, Active Contours, Active Shape Models, Active Appearance Models; Image Compression -Entropy coding, lossless JPEG, perceptually lossless coding, quantization,JPEG,JPEG2000; Image Quality - Natural scene statistics, quality assessment based on structural and statistical approaches, blind quality assessment; Statistical tools - Kalman Filter, Hidden Markov Models; Video Processing - Video standards, motion estimation, compression.

Soma Biswas , Rajiv Soundararajan

Pre-requistes : None

References : David A. Forsyth and Jean Ponce, Computer Vision: A Modern Approach,Pearson Education, 2003,Richard Szeliski, Computer Vision: Algorithms and Applications, Springer, 2010. Simon J.D. Prince, Computer Vision: Models, Learning, and Inference, Cambridge University Press, 2012.

E9 306 (JAN) 1 : 2

Machine Learning in Neuroscience

Signal, image processing and machine learning applications to recent trends in neuroscience research, such as auditory neuroscience; brain computer interface; biofeedback; sleep research; neural mechanisms and rehabilitation in coma;analysis of infradian, circadian and ultradian rhythms; interrelationships between biological signals; connectome and functional connectivity analysis.

Ramakrishnan A G

Pre-requistes : None

References : (1) Rao, Rajesh PN. Brain-computer interfacing: an introduction. Cambridge University Press, 2013. (2) Sebastian Seung. Connectome: How the brain's wiring makes us who we are. HMH, 2013. (3) Gazzaniga, M.S.The cognitive neurosciences. MIT press, 2009. (4) Dunlap, J.C., Loros, J.J. and DeCoursey, P.J. Chronobiology: biological timekeeping. Sinauer Associates, 2004. (5) Berry,Richard

EP 299(EE) (JAN) 0 : 24

Dissertation Project

Soma Biswas

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

Pre-requistes : None

References :
1. Bemporad, Alberto, Maurice Heemels, and Mikael Johansson. Networked control systems. Vol. 406. London: Springer, 2010.~2. Yüksel, Serdar,

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.

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

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

SP 299 (JAN) 0 : 28

Project

MTech SP Project

Prasanta Kumar Ghosh

Pre-requistes : None

References : None

E0 350 (JAN) 3 : 1

Advanced Convex Optimization

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

Kunal Narayan Chaudhury

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

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

E6 227 (JAN) 3 : 0

Power Electronics Design

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

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

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

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

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

Vishnu Mahadeva Iyer

Pre-requistes :
E6 201: Power Electronics

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

E0 298 (AUG) 3 : 1

Linear Algebra and Its Applications

[A] Theory: Solution of linear equations, vector space, linear transformations, matrix representation, inner products and norms, orthogonality, trace and determinant, eigenvalue decomposition, symmetric (Hermitian) matrices and quadratic forms, singular value decomposition.

[B] Applications: linear regression and normal equation, linearly constrained optimization, optimal subspace and low-rank approximations, dynamical systems, Markov chains, closest orthogonal transform, graph Laplacian and connectivity.

Pre-requistes : none.

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

E9 222 (JAN) 0 : 3

Signal Processing in Practice

1. Introduction to Python, Matlab, Latex

2. Effective technical communication, content generation for reports

3. Discrete Fourier transform, cosine transform, Karhunen-Loeve transform

4. Noise types and their power spectra

5. Speech denoising using transform-domain processing

6. Short-time Fourier transform

7. Sampling

8. Linear prediction/autoregressive modeling

9. Basics of 5G and experiments using a network simulator (orthogonal frequency division multiplexing)

10. Image denoising and enhancement, edge-aware filtering, convolutional neural networks for image classification

11. Exercises on image processing and optimization for image recovery

12. Exercises on array signal processing, graph signal processing

13. Exercises on machine learning for a speech/image processing application

Chandra Sekhar Seelamantula

Pre-requistes : Undergraduate course in Signals and Systems, Digital Signal Processing, Engineering Mathematics

References : Lab Manual that will be prepared by the M.Tech.(SP) Program Curriculum Committee specifically for this course.

In addition, the instructors will suggest selected reading material from the following references:

E9 310 (JAN) 3 : 1

Computational Imaging

Sensing: Introductory Fourier optics, characterization of image sensors, introduction to the human visual system, dynamic vision sensors

Basic optimization methods: Gradient-descent method, Majorization-minimization method, Proximal-gradient method, Dual Proximal-gradient method, Alternating Direction Method of Multipliers.

Computational formulations of inverse problems in imaging: Regularization methods, Tikhonov regularization, wavelet regularization, total-variation regularization, an overview of compressive sensing, end-to-end deep convolution neural networks, deep-unfolding methods, plug-and-play method, case-studies for some standard inverse problems.

Standard imaging modalities: Physical principles and numerical aspects of forward models for standard imaging modalities such as ultrasound imaging, optical coherence tomography, computerized tomography, magnetic resonance imaging, photoacoustic tomography, and positron emission tomography.

Unconventional imaging modalities: Single-pixel imaging, Coded diffraction imaging, lensless imaging, DiffuserCam, HDR imaging, Light-field imaging, Neuromorphic imaging

Chandra Sekhar Seelamantula

Pre-requistes :
Pass grade in Linear Algebra or Matrix Theory, and any introductory course on Optimization Methods. Consent of the instructors.
References : A. Beck, First-order methods in optimization, MOS-SIAM Series in Optimization.

M. Elad, Sparse and Redundant Representations, Springer.

E1 248 (JAN) 3 : 0

Sliding mode control and its applications

Module 1: Preliminaries–
1. A brief introduction to state space representation
2. Controllability and observability
3. Fundamentals of nonlinear systems, linearization of nonlinear systems with examples
4. Stability analysis tool: Lyapunov's stability theorem, Lyapunov based control design

Module 2: Sliding mode control–
1. Theory of conventional sliding mode: Filippov theory, reaching laws, finite-time stability, equivalent control method, advantages of sliding mode control
2. Introduction to second order sliding mode: relative degree, twisting algorithm, super twisting algorithm (as controller, differentiator, and observer)
3. Higher order sliding mode (as continuous controller and differentiator)
4. Terminal sliding mode control: fast terminal sliding mode control, non singular terminal sliding mode, prescribed convergence law
5. Integral sliding mode control
6. Discrete-time sliding mode control: Gao's reaching law, Bartoszewicz's reaching law

Module 3: Applications– Inverted pendulum, power convertors and power systems, quadrotors, etc. These will be covered as a part of the course project.

Module 4: Optional topics : sliding mode observers, multi-rate output feedback based control.

Kiran Kumari

Pre-requistes :
Any basic course on control theory, E0 298: Linear Algebra And Its Applications
References : 1. Sliding mode control and observation (Vol. 10. New York: Springer) by Yuri Shtessel, Christopher Edwards, Leonid Fridman, and Arie Levant, 2014.
2. Applications of sliding mode control (Vol. 79. Springer Singapore) by Derbel, Nabil, Jawhar Ghommam, and Quanmin Zhu, 2017.

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.

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.

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

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.

Pre-requistes : None

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

E3 200 (AUG) 1 : 2

Microelectronics Lab

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

Pre-requistes : None

References : None

E3 204 (JAN) 3 : 0

Fundamentals of MOS Analog Integrated Circuits

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

Sanjiv Sambandan

Pre-requistes : None

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

E3 225 (JAN) 3 : 0

Art of Compact Modeling

Santanu Mahapatra

Pre-requistes : None

References : None

E3 230 (JAN) 2 : 1

Essential Circuits for System Design

Umanand L

Pre-requistes : None

References : None

E3 231 (JAN) 2 : 1

Digital Systems Design with FPGAs

Introduction to Digital design; Hierarchical design, controller (FSM), case study, FSM issues, timing issues, pipelining, resource sharing, metastability,synchronization, MTBF Analysis, setup/hold time of various types of flip-flops, synchronization between multiple clock domains, reset recovery, proper resets. VHDL: different models, simulation cycles, process, concurrent and sequential statements, loops, delay models, library, packages, functions, procedures,coding for synthesis, test bench. FPGA: logic block and routing architecture,design methodology, special resources, Spartan-6 architecture, programming FPGA, constraints, STA, timing closure, case study.

Kuruvilla Verghese

Pre-requistes : None

References : Digital Design: Principles and Practices By J.F. Wakerly, Pearson~VHDL for Programmable Logic, By Kevin Skahill, Pearson~FPGA Data Sheets, Application Notes~Current Literature

E3 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;

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.

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.

Pre-requistes : None

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

E3 276 (JAN) 2 : 1

Process Technology and System Engineering for Advanced Microsensors and Devices

Introduction and Overview of Microfabrication Process Technology: Classification of Cleanrooms, Standard Operating Procedures for Working in a Conventional Clean Room Environment: Gowning Procedure, Operating Conditions,Clean Room Protocols, Safety and Contamination Issues in a Cleanroom, Overview of Cleanroom Hazards, Overview of Processes used in the Fabrication of Microsensors and Devices; Silicon Wafers - From Sand to the Laboratory:Silicon Growth Techniques: Czochralski and Float Zone, Wafer Processing from Si Ingot, Wafer Types: Crystallographic Planes, Physics of Silicon as a Semiconductor, Crystal Defects, Silicon Wafer Cleaning Methods: Piranha, RCA-1, RCA-2 using Wet-Benches; Thin Film Growth and Deposition Techniques: Thermal Oxidation, The Deal-Grove Model of Oxidation, Rate coefficients, Wet and Dry Oxidation, Overview of Oxidation Furnaces, Oxide Defects and ways of Mitigating it During Process Run, Contamination Control in the Furnace, Vacuum Systems: Construction and

Hardik J Pandya

Pre-requistes : None

References : None

E3 282 (AUG) 3 : 0

Basics of Semiconductor Devices and Technology

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

Pre-requistes : None

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

E6 202 (JAN) 2 : 1

Design of Power Converters

Power semiconductor switches, drive circuits for MOSFETs and IGBTs, snubber circuits, rectifier circuits, dc-dc switched mode converter circuits, pulse width modulation, non-isolated and isolated converters, magnetics for switched mode power conversion, design of magnetics, magnetic amplifiers, inverter circuits-self oscillating and driven inverter circuits, efficiency and losses in power electronic circuits, thermal issues and heat sink calculation.

Umanand L

Pre-requistes : None

References : Mohan N, Undeland T M, Robbins W P, Power Electronics: Converters, Applications and Design, John Wiley and Sons, NY, USA,Kitsum K, Switched Mode Power Conversion - Basic Theory and Design, Marcel Dekker, Inc, NY, USA,Rashid M H, Power Electronics, Circuits, Devices and Applications, Prentice Hall, NJ,USA

E6 212 (JAN) 3 : 0

Design and Control of Power Converters and Drives

Basics of phase controlled converters, Choppers, Front end Ac to DC converter, DC motor speed control, inverters, six step operation, sinusoidal PWM control, current hysteresis PWM and space vector PWM control of three phase inverters. Generation of the three phase PWM signals from sampled reference phase amplitudes and PWM control in overmodulation region, Speed control of induction motor; V/f operation, dynamic equivalent circuit model of induction motor and vector control of induction motor. Current source inverter, Multilevel inverters and its control.

Gopakumar K

Pre-requistes : None

References : Leonhard W, Control of Electrical Drives, Springer-Verlag, 1985,Mohan N, Undeland T M, Robbins, W P, Power electronics : Converters, Drives and application, John Wiley, NY, USA,Umanand L, Power electronics : Essentials and applications, Wiley India, 2009

E9 252 (JAN) 3 : 0

Mathematical methods and techniques in signal processing

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

Shayan Garani Srinivasa

Pre-requistes : None

References : None

AI 299 (AUG) 0 : 21

MTech AI Dissertation Project

MTech AI Dissertation Project

Chetan Singh Thakur

Pre-requistes : None

References : None

E3 257 (JAN) 2 : 1

Embedded System Design

Development toolchain (Compiler, Linker and Debugger), ARM Cortex processor architecture, Memory subsystem, caching, interfacing and programming peripherals, GPIO, UART, I2C, SPI, interrupts and NVIC architecture, interrupt driven standalone system

Dagale Haresh Ramji

Pre-requistes : None

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

ED 299 (JAN) 0 : 25

MTech ESE Dissertation Project

MTech ESE Dissertation Project

Umanand L

Pre-requistes : None

References : None

E3 203 (JAN) 2 : 1

Design of Analog Electronics and Industrial Instru

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

Arup Polley

Pre-requistes : None

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

E2 270 (AUG) 3 : 0

Quantum Information Theory

Overview of concepts from classical Shannon theory, noiseless quantum theory, noisy quantum theory and purified quantum theory, distance measures, quantum information and entropy, information of quantum channels, quantum typicality, packing lemma, covering lemma, Schumacher compression, entanglement concentration, noisy quantum Shannon theory, product measurements at the decoder, information-processing task, classical capacity theorem, superadditivity of Holevo information, entanglement-assisted classical communication

Pre-requistes : some background or familiarity in classical information theory

References : • Mark M. Wilde, “Quantum Information Theory”, Cambridge University Press
• M. Hayashi “Quantum Information Theory: A Mathematical Foundation” Springer-Verlag
• John Preskill Notes

E6 205 (AUG) 2 : 1

Design of Electric Motors

Importance of Motor Design, Electric and Magnetic Loading, , Concepts of BH Curves and Material Properties, Magnetic Circuits Applied to Electrical Machines, Flux Path Calculations, Design of Electrical Windings and MMF Distribution (DC Machine Windings: like a lap, wave, ring, commutator etc; AC Machine Windings), Winding Design Variable Speed Machines, Generalized Theory for Design of Electrical Machines (volume, power density, windings, core, standards, power loss, efficiency and etc.), Induction Motor Design, DC machine design, Special Machines Design (Switch Reluctance Machine Design), Thermal and Insulation Design, JMAG Electromagnetic FEM analysis of Different Machines.

Pre-requistes : None

References : 1. Thomas A. Lipo, Introduction to AC Machine Design, IEEE Press, John Wiley & Sons, Inc., NJ, USA.
2. Alexander Gray, Electrical Machine Design - The Design And Specification Of Direct And Alternating Current Machinery, Mc Graw Hill, NY, USA.
3. Krishnan, R., Switched Reluctance Motor Drives: Modeling, Simulation, Analysis, Design, and Applications, CRC Press, USA.

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

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.

ET 299 (JAN) 0 : 31

MTech EPD Dissertation Project

MTech EPD Dissertation Project

Umanand L

Pre-requistes : None

References : MTech EPD Dissertation Project

E3 273 (JAN) 2 : 1

Microcontroller and its Applications

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

Ramachandran P.

Pre-requistes : None

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

E3 343 (JAN) 1 : 2

Discrete Control and Estimation

Introduction to discrete state space control, circuit averaging, space vector modeling, linearization, discrete full state feedback, state augmentation, discrete full order estimation, discrete reduced order estimation, discrete optimal estimation, discrete LQR, discrete robust control.

Umanand L

Pre-requistes :
Background in classical control in discrete domain, state space representation, z-transform, microcontroller implementation

References : Digital Control of Dynamic Systems, Franklin, Workman and Powell, Addison-Wesley
Applied Optimal Control and Estimation, F L Lewis, Prentice Hall

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

PS 301 (JAN) 3 : 0

S and T POLICY DISCUSSIONS

Part 1 – Policy dynamics The module will begin with an overview of dynamics of policy formulation, policy process and policy analysis. Further policies from three domains will be discussed, namely, monetary/fiscal, energy and environment, and IP/technology/innovation. Within the domains, the policy instruments, their objectives, implementation, and impacts will be explored with reference to evidence from India and OECD countries. The essay paper will explore global comparison and policy concerns. Part 2 – Telecom policy The module will begin with an overview of the technology and the evolving eco system for which content processing, distribution, and delivery to end users, market structures in various segments, of this eco system, the National Telecom Policy, and the regulatory structure in India. In the second half of the course, we will do a deep dive into specific topics like net neutrality, spectrum management, standardization, Interconnections, economic impact of telecommunication, regulatory issues that may arise in emerging technologies. Part 3 – Data economics and policy The module will provide an introduction to the rapidly emerging area of data policy and economics. It will begin with a study of the privacy and individual rights associated with personal data, including an examination of the upcoming Personal Data Privacy bill, an exploration of how personal data be used in a responsible way to create public good without violating these rights, and several related topics. The course will also examine non-personal data, addressing the issues of data sharing, data ownership rights, fiduciary responsibility for community owned data, and data trusts and data trustees. Also covered will be some models for data monetization, studying some use cases where data has been used to create immense value, while also benefitting society.

Anjula Gurtoo

Pre-requistes : None

References : 1.Understanding Public Policy, 15th Edition – Thomas Dye 2.Readings from various academic papers

PS 303 (JAN) 2 : 0

Communicating science to non-experts

Course Content:
• Fundamentals of effective public and professional science communication
• Communication: A two-way street (How to seek and receive feedback for your communication)
• Improvisation exercises
• Role of science communication in science/society dialogue (situational/roleplay exercises)
• Using effective science communication for professional development (Setting up new inter-disciplinary collaborations)
• Narrative structure in communication
• 'Elevator pitches' at poster sessions (1 min, 3 min summary of work at scientific conferences)
• Science communication/outreach/journalism as a career choice

Learning outcomes:
By the end of the course, students will be able to:
1. Realize the jargon in the description of their research
2. Learn how to pitch their research in an engaging and exciting manner
3. Consider the various need of a large and diverse interdisciplinary audience

Mohit Kumar Jolly

Pre-requistes : None

References : 1. Don't be such a scientist, Island Press, 2009
2. Am I making myself clear? A Scientist's Guide to talking to the public, Harvard University Press, 2012
3. The Science of Scientific Writing, American Scientist, 1990

PS 223 (JAN) 1 : 0

Open Science: Policy and Practice

This modular (1-credit) course, to be taught during the second half of the January Term, is an introduction to policies to promote Open Science practices.

Course content: Historical accounts of open science and scholarly communications; Diversity of scholarly communication approaches in different disciplines; The current models of scholarly communications and copyright law; Copyright as user's right, exceptions, and limitations relating to educational and research uses; The case against the current model of scholarly publication & future of scholarly communication; Importance of open science in STI ecosystem; Open science: policy & practices

Abinandanan T A

Pre-requistes :
None.
None.
References : 1. Open Access by Peter Suber: https://mitpress.mit.edu/books/open-access
2. Open Access: Tearing Down Barriers Author(s): P. Balaram
3. S. Bartling and S. Friesike (eds.), Opening Science, DOI: 10.1007/978-3-319-00026-8_1, Ó

PS 222 (JAN) 1 : 0

STI Policy: Introduction and Contemporary Issues

This modular (1-credit) course, to be taught during the first half of the January Term, is designed as an introductory module in S&T policy with specific focus on Indian perspectives.

This course will provide:
- basic concepts and on-going debates in STI policy in India
- overview of governing institutions, stakeholders, and policy processes
- an opportunity to build deeper insights into some of the contemporary policy issues.

Course content:
Fundamentals of Public Policy; Concepts in Science, Technology, and Innovation (STI); Science as a social activity; Systems of innovation; Public policy and STI; Public / Government support and funding of science; Policy process: Evidence synthesis; Stakeholder consultations; Policymaking, cross-linkages, implementation, assessment, evaluation;

Impact & Evolution of STI Policies in India; SPR-1958, TPS-1983, STP-2003, STIP-2013, Draft STIP-2022

Case Studies on: Challenges in policy-program translation and stakeholder ownership; Comparative case study on policy processes of SPR 1958, TPS 1983, STP 2003, STIP 2013 and 5th national STIP; AI Ethics / Cross-broader Data governance.

Debates on: Rethinking national research funding; Future of STEM workforce

Abinandanan T A

Pre-requistes :
None.

References : 1. Nichols, Rodney. (2011). The Science of Science Policy: A Handbook – Edited by Kaye Husbands Fealing, Julia I. Lane, John H. Marburger III, and Stephanie S. Shipp. Review of Policy Research. 28. 10.1111/j.1541-1338.2011.00523.x.

Biosystems Science and Engineering

Preface

BE 203 (AUG) 0 : 1

Bioengineering Practicum 1

Rachit Agarwal , Ajay Sanjay Tijore

Pre-requistes : None

References : None

BE 204 (AUG) 0 : 1

Bioengineering Practicum 2

Rachit Agarwal , 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.

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

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

Pre-requistes : None

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

BE 211 (AUG) 3 : 0

Cell Mechanics

This course will provide an in-depth understanding of mechanics of the cell including theory of cellular architecture, mechanical forces, deformations,and adhesions, leading up to force generation and interaction of cells with the external environment. Additionally, practical aspects, includingmeasurement of cell mechanics using experimental techniques such asmicropipette aspiration, single particle tracking and atomic force microscopy will be presented. The topics covered will culminate in broad applications of cell mechanics in physiology, cell biology and biophysics with the syllabus comprising cell shapes, biomaterials (soft filaments and sheets in cells),forces inside cells, random walks, movement in a viscous fluid, viscoelasticity (background, constitutive models and measurement in cells),complex filaments, rheology of cytoskeletal filaments, biomembrane (bilayers, micelles, vesicle formation), cell-cell and cell- matrix interactions, micropipette aspiration, single particle tr

Pre-requistes : None

References :
David Boal, Mechanics of the Cell, Cambridge University Press(2012) ~Christopher R. Jacobs, Hayden Huang, Ronald Y. Kwon, Introduction to

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

Pre-requistes : None

References : None

BE 214 (JAN) 2 : 0

Fundamentals of Bioengineering 2

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

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

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

Rachit Agarwal , Medhavi Vishwakarma

Pre-requistes : None

References : Biomaterials Science, B.D. Ratner et. al., 3rd Edition, Academic Press,2012. A Textbook of Biomechanics, S. Pal, Viva Books, New Delhi,India, 2009

BE 215 (AUG) 3 : 0

Chemistry for Bioengineers

This course aims to provide a fundamental understanding of chemistry to bioengineers so they can harness these concepts to solve bioengineering research challenges. The main topics that will be covered in this course are the following:
1. Bonding models including valence bond theory, molecular orbital theory, chemical forces- types and applications on biological /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

Pre-requistes : None

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

BE 218 (JAN) 3 : 1

Computational Epidemiology

• Introduction to epidemiology. SIR modelling from the microscopic to the macroscopic, herd immunity. Compartment models (location compartments, age compartments, disease compartments), impact on herd immunity, social distancing, masking. Parameter fitting for SIR models. Clinical studies and disease biology. Agent-based models – general description, network generation and computational aspects, contact tracing, transport modelling, calibration, validation. Stages of the pandemic (pre-pandemic, acceleration, mitigation, suppression, and post pandemic) and associated modelling (non-pharmaceutical interventions, therapeutics, vaccinations). Seroprevalence studies, sampling methods, biases, and how to handle them. Miscellaneous topics – a subset of mobility modelling, migration patterns, communication about the pandemic, behavioural changes and its monitoring, contact tracing apps, digital apps like Aarogya Setu, testing logistics, workplace readiness

Rajesh Sundaresan

Pre-requistes :
A reasonable preparation in computational mathematics – modelling and analysis.
References : • Saracci, R., 2010. Epidemiology, A Very Short Introduction. Oxford University Press. Clayton, D. and Hills, M., 2013. Statistical models in Epidemiology. Oxford University Press. Chakraborty A. K. and Shaw A., 2021. Viruses, Pandemics, and Immunity. A K Chakraborty and A Shaw, Illustrated by P J S Stork, MIT Press. Rothman, K.J., Greenland, S. and Lash, T.L., 2008. Modern epidemiology

BE 226 (JAN) 2 : 0

Synthetic Biology and Genetic Engineering

Synthetic biology and genetic engineering is an emerging field that spans the boundary of biology, engineering, and physical sciences with its goal of engineering biomolecular systems and cellular capabilities for a variety of applications. This course aims to offer an introduction to this rapidly evolving field and equip students with foundational skills and critical mindsets. The course will cover following modules: Overview of the principles of heredity and gene manipulation; Central dogma: transcription, reverse transcription, translation, posttranslational modification; Highlight how gene manipulation can be applied to engineer simple and complex life forms; Gene Manipulation: Polymerase Chain Reaction, DNA modifying enzymes, strategies for gene cloning, gene editing, Crispr/Cas9, vectors, selection & screening, sequencing DNA; Gene transfer to animal cells & transgenic animals, gene transfer to plant cells & transgenic plants; In vitro/cell-free systems; Applications: Biomedicine, Biofuels, Bioremediation; Safety and ethical considerations.

Deepak Kumar Saini , Saravanan Palani

Pre-requistes :

NIL

References : Synthetic Biology: Tools for Engineering Biological Systems (Perspectives Cshl) by Daniel G Gibson (Editor), Clyde A Hutchison III (Editor), Hamilton O Smith (Editor), J Craig Venter (Editor)

BE 224 (JAN) 3 : 0

Diagnostics and Devices

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

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

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

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

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

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

Sanhita Sinharay

Pre-requistes : None

References : Molecular Imaging: Principles and practices – Ralph Weissleder

BE 223 (AUG) 2 : 0

Space Biology and Bioengineering

Human Space programs around the world are moving at a fast-pace and these developments have created a strong need and interest in understanding the effect of outer-space on biological systems. This course is intended to be an introductory course, which will focus aspects of space biology such as extreme microbiology, astrobiology, and understanding of effect of space stressors on biological systems.

Details of course topics:
• Introduction aspects of space biology, extreme microbiology, computational biology for space biology.
• Biological payload design – concepts and design considerations. Use of such payloads to study various systems in available platforms such as PSLV missions.
• Biocementation: Discussion on biocementation capable organisms with a focus on certain biocementation capable microbes that can also tolerate extreme conditions. Biocementation and possible application to extra-terrestrial habitats and terraforming.
• Astrobiology, and understanding of space stressors such as microgravity, radiation, and temperature on biological systems.
• Demonstration of lab-scale simulated microgravity and associated effects.

Pre-requistes :
A background in Microbiology is desirable.

References : Class Notes

BE 222 (JAN) 3 : 0

Stem Cell Technology

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

Medhavi Vishwakarma , Ajay Sanjay Tijore

Pre-requistes : None

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

BE 221 (JAN) 3 : 0

Introduction to Data Science for Bioengineers

Bioengineering research often generates large amounts of data, analysis of which requires sound technical knowledge of data sciences. The goal of this course is to introduce students to the basic concepts and tools of statistical and machine learning, which may be useful to analyse the data generated by the medical, biological, and bioengineering community. The following topics will be covered: introduction to descriptive statistics, introduction to probability theory, discrete and continuous probability distributions, estimation, hypothesis testing, introduction to statistical learning, linear regression, analysis of categorical data, logistic regression, linear-discriminant analysis and KNN method, datasets and resampling, dimensionality reduction, support vector machines, unsupervised learning including machine learning. Problems will be presented and solved using R.

Siddharth Jhunjhunwala

Pre-requistes :
1. Undergraduate level course in probability and statistics, or an undergraduate course in Biostatistics; OR

References : There is no prescribed textbook for this course. But the following reference texts are suggested:
1. Fundamentals of Biostatistics, Bernard Rosner
2. An Introduction to Statistical Learning, Gareth James et al.

BE 220 (JAN) 2 : 0

Industry Seminar

This goal of the course is to acquaint students to best practices followed by the industries in the domains of Bioengineering, Biotechnology, Pharmaceutical technology, and Healthcare. The course is designed as a 3-hour interaction with experts from the industry once every 10 days. Specifically, the expert will begin with a 1-hour lecture describing their domain knowledge, the solutions developed by their company, and providing insight into how ideas are converted into products that may be used by other businesses and consumers. Following the lecture, a 1-hour group-interaction between students and the expert will be conducted. The final 1-hour will be dedicated to an internal discussion among the students and the course instructor on applying the theoretical concepts learned as part of the Bioengineering curriculum, to solving problems faced by the industry. A total of 10 lectures are planned through the semester, totalling 30 contact hours.

Siddharth Jhunjhunwala

Pre-requistes :
None

References : There is no prescribed textbook for this course.

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

Pre-requistes :
None

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.

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 201 (AUG) 2 : 1

Micro and Nano Characterization Methods

This course provides training in the use of various device and material characterization techniques. Optical characterization: optical microscopy,thin film measurement, ellipsometry, and Raman spectroscopy; Electrical characterization: Noise in electrical measurements, Resistivity with 2- probe,4-probe and van der Pauw technique, Hall mobility, DC I-V and High frequency C-V characterization; Mechanical characterization: Laser Doppler vibrometry,Scanning acoustic microscopy, Optical profilometry, and Micro UTM; Material characterization: Scanning electron microscopy, Atomic force microscopy, XRD,and Focused ion beam machining.

Akshay K Naik

Pre-requistes : None

References : None

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 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.

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

Pre-requistes : None

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

NE 221 (JAN) 2 : 1

Advanced MEMS Packaging

This course intends to prepare students to pursue advanced topics in more specialized areas of MEMS and Electronic packaging for various real time applications such as Aero space, Bio-medical, Automotive, commercial, RF and micro fluidics etc. MEMS – An Overview, Miniaturisation, MEMS and Microelectronics -3 levels of Packaging. Critical Issues viz., Interface,Testing & evaluation. Packaging Technologies like Wafer dicing, Bonding and Sealing. Design aspects and Process Flow, Materials for Packaging, Top down System Approach. Different types of Sealing Technologies like brazing,Electron Beam welding and Laser welding. Vacuum Packaging with Moisture Control. 3D Packaging examples. Bio Chips / Lab-on-a chip and micro fluidics, Various RF Packaging, Optical Packaging, Packaging for Aerospace applications.Advanced and Special Packaging techniques – Monolithic, Hybrid etc.,Transduction and Special packaging requirements for Absolute, Gauge and differential Pressure measurements,Temperature measurements, Accelerometer and Gyro packaging techniques, Environmental Protection and safety aspects in MEMS Packaging. Reliability Analysis and FMECA. Media Compatibility Case Studies,Challenges /Opportunities/ Research frontier.

Prosenjit Sen

Pre-requistes : None

References : Tai-Ran Hsu, MEMS PACKAGING, INSPEC, The Institution of Electrical Engineers,London,UK,2004,Tai-Ran Hsu, MEMS & MICRO SYSTEMS Design and Manufacture, Tata McGraw Hill, New Delhi,2002,John H Lau, Cheng Kuo Lee, C.S. Premchandran, Yu Aibin, Advanced MEMS Packaging, McGraw-Hill, 2010

NE 222 (AUG) 3 : 0

MEMS: Modeling, Design, and Implementation

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

Pre-requistes : None

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

NE 223 (JAN) 2 : 1

Analog Circuits and Embedded System for Sensors

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

Saurabh Arun Chandorkar

Pre-requistes : None

References : None

NE 231 (AUG) 3 : 0

Microfluidics

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

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 241 (JAN) 3 : 0

Material Synthesis : Quantum Dots to Bulk Crystals

All device fabrication is preceded by material synthesis which in turn determines material microstructure, properties and device performance. The aimof this course is to introduce the student to the principles that help control growth. Crystallography ; Surfaces and Interfaces; Thermodynamics, Kinetics,and Mechanisms of Nucleation and Growth of Crystals ; Applications to growth from solutions, melts and vapors (Chemical vapor deposition an Physical vapor deposition methods); Stress effects in film growth

Pavan Nukala

Pre-requistes : None

References : Ivan V. Markov, Crystal growth for Beginners, Fundamentals of Nucleation, Crystal Growth and Epitaxy, World Scientific, 1998. (548.5,N96),~L.B.Freund, S. Suresh, Thin Film Materials – Stress, Defect Formation and Surface Evolution,Cambridge University Press, 2003. (621.38152 PO36)~Milton Ohring, Material Science of Thin Films, Academic Press,-,-~-~-

NE 250 (AUG) 1 : 0

Entrepreneurship, Ethics and Societal Impact

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

Pre-requistes : None

References : None

NE 299 (JAN) 0 : 27

Dissertation Project

Supradeepa V R

Pre-requistes : None

References : None

NE 310 (JAN) 3 : 0

Photonics technology: Materials and Devices

Optics fundamentals; ray optics, electromagnetic optics and guided wave optics, Light-matter interaction, optical materials; phases, bands and bonds,waveguides, wavelength selective filters, electrons and photons in semiconductors, photons in dielectric, Light-emitting diodes, optical amplifiers and Lasers, non-linear optics, Modulators, Film growth and deposition, defects and strain, III-V semiconductor device technology and processing, silicon photonics technology, photonic integrated circuit in telecommunication and sensors.

Shankar Kumar Selvaraja

Pre-requistes : None

References : Saleh, B. E. A., and M. C. Teich. Fundamentals of Photonics. New York, NY: Wiley, 1991.,T. Tamir, Topics in Applied Physics Volume 7:Integrated Optics,Springer-Verlag Berlin.,Haus, H. A. Waves and Fields in Optoelectronics. Englewood Cliffs, NJ: Prentice-Hall.,Research articles,,Handouts and Lecture

NE 312 (JAN) 3 : 0

Nonlinear and Ultrafast Photonics

Supradeepa V R , Varun Raghunathan

Pre-requistes : None

References : None

NE 313 (AUG) 3 : 0

Lasers: Principles and Systems

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

Pre-requistes : None

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

NE 314 (JAN) 3 : 0

Semiconductor Opto-electronics and Photovoltaics

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

Sushobhan Avasthi , Aditya Sadhanala

Pre-requistes : None

References : None

NE 332 (JAN) 3 : 0

Physics and Mathematics of Molecular Sensing

This course presents a systematic view of the process of sensing molecules with emphasis on bio-sensing using solid state sensors. Molecules that need to be sensed, relevant molecular biology, current technologies for molecular sensing, modeling adsorption-desorption processes, transport of target molecules, noise in molecular recognition, proof-reading schemes, multi- channel sensing, comparison between in-vivo sensing circuits and solid state biosensors

Manoj Varma

Pre-requistes : None

References : None

NE 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.

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 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

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 311 (JAN) 1 : 1

Integrated photonics Lab

The course envisages giving students hands-on integrated photonic device design and characterization skills. The course covers device design concepts using EDA tools and a custom simulation framework as well. The designs will be fabricated through the CeNSE fabrication facility, and the course students will characterize the devices. The integrated photonic devices that we shall study find applications in optical communication, on-chip photonic sensor, quantum photonic integrated circuit, and neuromorphic photonic circuit. The following are the specific devices that the students will design as a part of their course. 1. Optical waveguides 2.Directional couplers 3. Light-chip coupler 4. Power splitters and combiner 5. Wavelength selective devices 6. Bragg filter 7. Photodetector 8. Light modulator 9. Mach Zehnder interferometers 10. Ring resonator The student will be exposed to design tools, methodology, fabrication and characterization of devices and circuits

Shankar Kumar Selvaraja

Pre-requistes : None

References : Fundamentals of Photonics, B.E.A Saleh and M.C. Teich, Wiley, New York, 1991 *Photonic Devices. Cambridge, J. Liu, Cambridge University Press, 2005. *Fundamentals of Optoelectronics, Clifford R. Pollock, Irwin, 1995. *Diode Lasers and Photonic Integrated Circuits, Larry A. Coldren Scott W. Corzine Milan L. Mašanović, Wiley-Interscience.

NE 315 (JAN) 3 : 0

Semiconductor devices for RF and microwave electronics

Device technologies in RF/microwave: LDMOS, SiGe HBT, GaAs MESFET & HEMT/p-HEMT, and GaN HEMTs, Transferred electron devices (IMPATT, Gunn diode), Esaki diodes, RTD, RITD Silicon LDMOS: device physics, current transport, breakdown, ON resistance, snapback, operating voltage considerations, Silicon LDMOS: design & layout, bond pad manifolds, metal design, frequency aspects – device dimensions GaAs MESFET: current transport, transconductance, device I-V and loadline, device design, recess/channel/gate/ field-plates, power cell design & combination, thermal design GaAs FETs: fabrication overview & process steps GaN HEMTs: operating principles, design & RF performance, leakage, dispersion, knee walkout, reliability Linear network analysis: impedance & admittance matrices, S-parameters, relationship between 2-port parameters Small-signal model (FETs) & determination of circuit elements, how to de-embed parasitics Derivation of cut-off frequenci(fT, fMax), MAG, MSG. Dependence of thes

Digbijoy N Nath

Pre-requistes : None

References : "Physics of semiconductor devices", by S M Sze, Wiley India “Fundamentals of III-V devices” by William Liu, Wiley International “Semiconductor Device Physics and Design”, by Umesh Mishra and Jasprit Singh, Springer “Fundamentals of RF and microwave transistor amplifiers” by Inder J. Bahl, Wiley International “Modeling and characterization of RF and microwave power FETs” by

NE 261 (JAN) 3 : 0

Piezoelectric MEMS: Theory, Design and Application

This is an introductory course that covers physics, design and analysis of Piezoelectric MEMS transducers. This course builds on the background provided in “NE222 MEMS: Modelling, Design, and Implementation”. This course gives the students exposure to elastic waves, wave propagation, transducer modelling, piezoelectric material physics, design of Piezo MEMS sensors and actuators, and RF MEMS – resonators, oscillators and filters. Specific case studies will include ultrasonic transducers, mass sensors, Surface Acoustic Wave resonators, and inertial sensors. Finite element modelling of varying mechanical and electrical boundary conditions will also be covered.

Gayathri Pillai

Pre-requistes : None

References : 1) Bhugra, Harmeet, and Gianluca Piazza, eds. Piezoelectric MEMS resonators. New York, NY, USA: Springer International Publishing, 2017.
2) Stephen D. Senturia, Microsystem Design, Kluwer Academic Publishers, 2000

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

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.

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 317 (JAN) 3 : 0

From natural to artificial intelligence

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

Sreetosh Goswami

Pre-requistes : None

References : 1. Minds Behind the Brain: A History of the Pioneers and Their Discoveries 1st Edition
2. Origins of Neuroscience: A History of Explorations into Brain Function Reprint Edition
3. Principles of Neural Science (Kandel)

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.

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.

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.

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

Pre-requistes : None

References : None

DS 256 (JAN) 3 : 1

Scalable Systems for Data Science

This course will teach the fundamental Systems aspects of designing and using Big Data platforms, which are a specialization of scalable systems for data science applications. 1) Design of distributed program models and abstractions, such as MapReduce, Dataflow and Vertex-centric models, for processing volume, velocity and linked datasets, and for storing and querying over NoSQL datasets. 2) Approaches and design patterns to translate existing data-intensive algorithms and analytics into these distributed programming abstractions. 3)Distributed software architectures, runtime and storage strategies used by Big Data platforms such as Apache Hadoop, Spark, Storm, Giraph and Hive to execute applications developed using these models on commodity clusters and Clouds in a scalable manner Students will work with real, large datasets and commodity clusters, and use scalable algorithms and platforms to develop a Big Data application. See http://cds.iisc.ac.in/courses/ds256/ for details

Yogesh L Simmhan

Pre-requistes : None

References : None

DS 260 (JAN) 3 : 0

Medical Imaging

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

Phaneendra Kumar Yalavarthy

Pre-requistes : None

References : None

DS 263 (AUG) 3 : 1

Video Analytics

Introduction to Digital Image and Video Processing, Background Modeling, Object Detection and Recognition, Local Feature Extraction, Biologically Inspired Vision, Object Classification, Categorization, Tracking, Activity Recognition, Anomaly Detection, Intrusion detection, Handling occlusion, scale and appearance changes.

Pre-requistes : None

References :
Richard Szeliski, Computer Vision: Algorithms and Applications, Springer 2010~Forsyth, D.A., and Ponce, J., Computer Vision: A Modern Approach,

DS 265 (JAN) 3 : 1

Deep Learning for Computer Vision

Computer vision – brief overview; Machine Learning – overview of selected topics ; Introduction to Neural Networks, Backpropagation, Multi-layer Perceptrons ; Convolutional Neural Networks ; Training Neural Networks ; Deep Learning Software Frameworks ; Popular CNN Architectures ; Recurrent Neural Networks ; Applications of CNNs Classification, Detection, Segmentation,Visualization, Model compression; Unsupervised learning; Generative Adversarial Networks.

Venkatesh Babu R

Pre-requistes : None

References : Current Literature

DS 284 (AUG) 2 : 1

Numerical Linear Algebra

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

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

Pre-requistes : None

References : None

DS 289 (JAN) 3 : 1

Numerical Solution of Differential Equations

Ordinary differential equations: Lipschitz condition, solutions in closed form, power series method. Numerical methods: error analysis, stability and convergence, Euler and Runge-Kutta methods, multistep methods, Adams-Bashforth and Adams-Moulton methods, Gear's open and closed methods, predictor-corrector methods. Sturm-Liouville problem: eigenvalue problems, special functions,Legendre, Bessel and Hermite functions. Partial differential equations:classification, elliptic, parabolic and hyperbolic PDEs, Dirichlet, Neumann and mixed boundary value problems, separation of variables, Green's functions for inhomogeneous problems. Numerical solution of PDEs: relaxation methods for elliptic PDEs, Crank-Nicholson method for parabolic PDEs, Lax-Wendroff method for hyperbolic PDEs. Calculus of variations and variational techniques for PDEs, integral equations. Finite element method and finite difference time domain method, method of weighted residuals, weak and Galerkin forms, ordinary and we

Konduri Aditya

Pre-requistes : None

References : None

DS 290 (AUG) 3 : 0

Modelling and Simulation

Pre-requistes : None

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

DS 295 (JAN) 3 : 1

Parallel Programming

1) Architecture: computer organization, single-core optimizations including exploiting cache hierarchy and vectorization, parallel 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. Parallel Algorithms: MPI collective communication algorithms including prefix computations, sorting, graph algorithms, GPU algorithms; Parallel Matrix computations: dense and sparse linear algebra, GPU matrix computations;Algorithm models: Divide-and-conquer, Mesh-based communications, BSP model;Advanced Parallel Programming Models a

Sathish S Vadhiyar

Pre-requistes : None

References : None

DS 299 (JAN) 0 : 28

Dissertation Project

This includes the analysis, design of hardware/software construction of an apparatus/instruments and testing and evaluation of its performance. The project work is usually based on a scientific/engineering problem of current interest. Every student has to complete the work in the specified period and should submit the Project Report for final evaluation. The students will be evaluated at the end first year summer for 4 credits. The split of credits term wise is as follows 0:4 Summer, 0:8 AUG, 0:16 JAN.

Debnath Pal

Pre-requistes : None

References : None

DS 202 (JAN) 2 : 1

Algorithmic Foundations of Big Data Biology

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

Chirag Jain

Pre-requistes : Knowledge of basic data structures, algorithms, programming experience, and DS-221 (or) DS-201 (or) E0-251 (or) E0-225 (or) consent from the Instructor

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

DS 226 (AUG) 2 : 1

Introduction to Computing for AI and Machine Learning

Programming Foundation: Fundamentals of digital storage of data, Performance of a computer, Caches, Debugging and Profiling, Basic optimization techniques for serial codes. Introduction to Object oriented programming: Object and Data Structure Basics, Python Statements, Methods and Functions, Object-oriented programming (OOP):Inheritance, Encapsulation, Abstraction, Polymorphism. OOP concepts in Python. OOP concepts in C++. Python tools for Data Science: Pandas, NumPy, Matplotlib, Scikit-Learn, Just-in-Time (JIT) compilers, Numba Computational Thinking: Arrays, Matrix-Vector, Matrix multiplication, Solving dense and sparse systems. Basic machine learning algorithms. Deep Learning with Open source AI/ML Packages: Tensors, TensorFlow basics, mlpack, Interface to mlpack, Simple statistics and plotting, Loading and exploring data, Learning with TensorFlow and Keras, Mini-project

Pre-requistes : Basic knowledge of mathematics, data structures, and algorithms.

References :
1.John Hennessy David Patterson. Computer Architecture. A Quantitative Approach. 6th edition, Morgan Kauffman, 2017.

DS 392 (JAN) 3 : 1

Environmental Data Analytics

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

Deepak Narayanan Subramani

Pre-requistes : DS 211 (Numerical Optimization), DS 221 (Introduction to Scalable Systems), DS 284 (Introduction to Numerical Linear Algebra), or equivalent and Consent of Instructor

References : 1. Géron, Aurélien. Hands-on machine learning with Scikit-Learn, Keras, and TensorFlow: Concepts, tools, and techniques to build intelligent systems. Second Edition. O'Reilly Media, 2019. 2. Särkkä, Simo. Bayesian Filtering and Smoothing. Cambridge University Press,2013. 3. Murphy, Kevin P. Machine Learning: A Probabilistic Perspective. MIT Press, 2012

DS 269 (JAN) 2 : 1

Computational Methods for Reacting Flows

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

Konduri Aditya

Pre-requistes : Basic knowledge in combustion (AE 241 or equivalent), numerical methods for differential equations (DS 289 or equivalent) and machine learnin (E0 229 or equivalent), or a consent from the instructor. Good proficiency in programming.

References :
1. An Introduction to Combustion, Stephen R. Turns, McGraw Hill, 2011.
2. Theoretical and numerical combustion, Thierry Poinsot and Denis

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

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

References :

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

DS 298 (JAN) 3 : 1

Random Variates in Computation

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

Topics:

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

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

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

Murugesan Venkatapathi

Pre-requistes : Undergraduate level statistics and graduate level linear algebra.

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

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

DS 261 (AUG) 3 : 1

Artificial Intelligence for Medical Image Analysis

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

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

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

DS 285 (JAN) 3 : 1

Tensor Computations for Data Science

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

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

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

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

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

Ratikanta Behera

Pre-requistes :
DS 284 - Numerical Linear Algebra, or MA219 - Linear Algebra with basic programming skills (in any programming language).
References : References (Books)

(1) Liu, Y. (Ed.). Tensors for Data Processing: Theory, Methods, and Applications.

Management Studies

Preface

MG 223 (JAN) 3 : 0

Applied Operations Research

Introduction to management decision making and operations research. Fundamentals of linear programming. Alternative ways of formulating practical linear programming models. Their advantages and disadvantages. Case studies and applications of linear programming. Solution approaches, implications of sensitivity analysis. Transportation and assignment programming. Sensitivity analysis in transportation programming; integer programming formulations and applications. Basics of heuristic optimization. Dynamic programming.Applications of dynamic programming [Entire course will use real-life business applications].

Mathirajan M

Pre-requistes : None

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

MG 261 (AUG) 3 : 0

Operations Management

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

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.

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.

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.

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.

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.

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.

Pre-requistes : None

References : None

MG 251 (JAN) 3 : 0

Finance and Accounts

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

Shashi Jain

Pre-requistes : None

References : None

MG 258 (AUG) 3 : 0

Financial instruments and risk management strategies

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.

Pre-requistes : None

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

MG 277 (JAN) 3 : 0

Public Policy Theory and Process

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

Anjula Gurtoo

Pre-requistes : None

References : Weimer,D.L.,and Vining A.R.,Policy Analysis: concepts and practice,Prentice Hall

MG 281 (JAN) 3 : 0

Management of Technology for Sustainability

Concepts of sustainability and sustainable development. Components of sustainability (social, economic, environmental). Linkages between technology and sustainability. Sustainability proofing of technology life cycle. Frameworks for measuring sustainability. Indicators of sustainability.Interactions between energy and technology and their implications for environment and sustainable development. Technological innovations for sustainability. Sustainable innovations – drivers and barriers. Policy and institutional innovations for sustainability transition.

Balachandra P

Pre-requistes : None

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

MG 298 (JAN) 3 : 0

Entreperneurship for Technology Start-ups

Bala Subrahmanya Mungila Hillemane

Pre-requistes : None

References : None

MG 299 (JAN) 0 : 16

Management Project

The project work is expected to give intensive experience for a student with respect to industrial organizations or institutions in the context of chosen field of specialization. Students are encouraged to carryout individual project works.

Parthasarathy Ramachandran

Pre-requistes : None

References : None

MG 220 (JAN) 3 : 0

Introductory Statistics

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

Mukhopadhyay C

Pre-requistes : MG219 or equivalent

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

MG 219 (AUG) 3 : 0

Introductory Probability Theory

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

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.

Pre-requistes : None

References : None

ER 205 (JAN) 3 : 0

Thermal Systems Design and Analysis

Basic equations of fluid mechanics, modified Bernoulli equation,major and minor head losses, pumps and piping systems,piping design problems, fans and air flow system design,heat exchanger design, sizing and rating, LMTD and NTU methods, shell and tube heat exchangers, compact heat exchangers, modelling thermal equipment, waste heat recovery systems, thermal system analysis and optimization methods, energy economics, solar collector and storage system design.

Pradip Dutta , Pramod Kumar

Pre-requistes : None

References : Text Books: 1)Thermal Design and Optimization by Bejan,Tsatsaronis & Moran 2)Design of Thermal Systems by W. Stoecker References: 1)F.P. Incropera and D.P. Dewitt, Introduction to Heat Transfer 2)Jaluria, Y., Design and Optimisation of Thermal Systems 3)Burmeister, L.C., Elements of Thermal-Fluid System Design 4)Janna, W.S., Design of Fluid Thermal Systems

Water Research

Preface

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.

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.

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

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

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.

Pre-requistes : None

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

CP 316 (JAN) 2 : 1

Real-time Embedded Systems

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

Pushpak Jagtap

Pre-requistes :
Embedded systems / C programming

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

CP 230 (JAN) 2 : 1

Motion Planning for Autonomous Systems

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

Debasish Ghose

Pre-requistes :
Familiarity with MATLAB, ROS/Gazebo; Exposure to mathematical concepts from linear algebra.
References : 1.S.M. LaValle, Planning Algorithms, Cambridge University Press,2006. 2.M.Mesbahi and M.Egerstedt, Graph Theoretic Methods in Multiagent Networks, Princeton Series in Applied Mathematics,2010. 3.J.-C. Latombe, RobotMotion Planning (Vol. 124). Springer Science & Business Media, 2012. 4.Current Literature

CP 315 (JAN) 2 : 1

Robot Learning and Control

This graduate course will explore the new area of interaction between learning and control specifically applied to robotic systems, both from a foundational level together with a view toward application. The course will first build the necessary framework in which to understand robotic systems, including robot kinematics and dynamics, sensing and estimation, machine learning and control. With these fundamentals the course will focus on data driven approaches for control.

Shishir Nadubettu Yadukumar

Pre-requistes :
Students must be well versed with basic mathematical concepts like linear algebra, classical analysis and probability theory. Suggested
References : Murray, Li and Sastry A Mathematical Introduction to Robot Manipulation, CRC Press, 1994. Sutton and Barto Reinforcement Learning: An Introduction, MIT Press, 2017. Sergey Levine Deep Reinforcement Learning http://rail.eecs.berkeley.edu/deeprlcourse/ Spong,Hutchinson and Vidyasagar Robot Modeling and Control, Wiley, 2005

CP 280 (JAN) 1 : 2

Experimental Techniques for Robotics and Automation

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

Suresh Sundaram

Pre-requistes :
. Familiarity with C programming
. Familiarity with any microprocessor and analog/digital circuits

References : 1.Probabilistic Robotics, S. Thrun Deep Learning, I Goodfellow Richard Szeliski, Computer Vision: Algorithms and Applications, Springer, 2010 (For the vision part). Course presentation slides 2. Robot Mechanisms and Mechanical Devices Illustrated by Paul Sandin 3. The OpenR/C Project by Daniel Norée (https://danielnoree.com/the- openrc-project/)

CP 260 (JAN) 2 : 1

Robotic Perception

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

Bharadwaj Amrutur

Pre-requistes :
Basics of Linear Algebra and Probability, Comfort with some programming language

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

CP 218 (JAN) 2 : 1

Theory and Applications of Bayesian Learning

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

Punit Rathore

Pre-requistes :
Basic knowledge of Linear Algebra, Probability, and Calculus, and Basic Programming knowledge (preferably in R or Python)
References : Probabilistic Graphical Models, Principles and Techniques,1st edition, Daphne Koller, Cambridge University Press,2009. Machine learning: A Probabilistic Perspective, Kevin Murphy, MIT Press, 2012. Pattern Recognition and Machine Learning, Christopher Bishop, New York, Springer, 2006. Bayesian Reasoning and Machine Learning, David Barber, Cambridge University Press, 2012

CP 210 (JAN) 1 : 0

Seminar CPS

Seminar in various topic in CPS

Pushpak Jagtap

Pre-requistes :
Nil

References :
Nil

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.

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 282 (AUG) 1 : 2

Field Robotics

Description

This is an experimental course for the students to get hands-on experience in putting together an end-to-end solution using robots. They will work in cohorts to learn simulation, programming, system design, solution development, prototyping and finally demonstration of their solutions.

Credits: 1:2

Course plan

Part 1: Exposure to the robot and experimental platforms

· Basics of Localization using MoCap system

· Basics of the chosen robot platform (e.g. quadcopters)

· Learning to operate the robots (e.g. learning to fly in case of drones)

· Basics of robot hardware and firmware (e.g. Autopilots and Mavros)

Part 2: Exposure to Simulation Frameworks

· Flight control understanding

· Exposure to Multi-Robot Simulation framework

· System design for the Main problem for the course

· Simulation of the proposed solution in the simulation framework

Part 3: Prototyping and demonstration

· Thrust Bench Test

· Script driven flying

· Flight training

· Assembling the drone

· Implementation of solution on the robot platform

· Testing and validation in the field.

Pre-requistes :

Prerequisites

References :

References/Texts:

1. Zhan Wang, Simultaneous Localization and Mapping: Exactly Sparse Information Filters: 3, World Scientific Publisher, 2011.

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

Pre-requistes : Undergraduate Engineering Mathematics courses that include: vectors, linear algebra, differential equations, facility with computers (This course will use Matlab and Gazebo/python, but facility with any programming language suffices as preparation).

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

CP 275 (JAN) 2 : 1

Formal Analysis and Control of Autonomous Systems

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

Pushpak Jagtap

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

CP 299 (JAN) 0 : 26

MTech Project

Project work under guidance of advisor(s)

Pushpak Jagtap

Pre-requistes : None

References : As per supervisor's recommendation

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.

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.

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.

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.

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.

Pre-requistes : None

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

AE 211 (JAN) 3 : 0

Mathematical Methods of Aerospace Engineers

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

Viveknand Dabade , Rajesh Chaunsali

Pre-requistes : None

References : Erwin Kreysig, Advanced Engineering Mathematics Wiley 2015.

AE 222 (JAN) 3 : 0

Gas Dynamics

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

Srisha Rao M V

Pre-requistes : None

References : Liepmann, H.W. and Roshko, A., Elements of Gas Dynamics, John Wiley, 1957.~Becker, E., Gas Dynamics Academic Press, New York, 1968.~Anderson, J.D.,Modern Compressible Flow, McGraw Hill, 1990.~Zucrow, M.J. and Hoffman, J.D.,Gas Dynamics, Vols. 1-2, Wiley, 1976.~Zucker, R.D. and Biblarz, O.,Fundamentals of Gas Dynamics, Wiley, 2002.

AE 225 (JAN) 3 : 0

Boundary Layer Theory

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

Sourabh Suhas Diwan

Pre-requistes : None

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

AE 226 (JAN) 3 : 0

Turbulent Shear Flows

Origin of turbulence, laminar-turbulent transition, vortex dynamics, statistical aspects of turbulence, scales in turbulence, spectrum of turbulence, boundary layers, pipe flow, free shear layers, concepts of equilibrium and similarity, basic ideas of turbulence modeling, measurement techniques.

Joseph Mathew

Pre-requistes : None

References : Tritton, D.J., Physical Fluid Dynamics, Oxford University Press. ~Tennekes, H.and Lumley, J., A First Course in Turbulence, M.I.T. Press. ~Townsend, A.A.,The Structure of Turbulent Shear Flow, Cambridge Univ. Press.

AE 241 (JAN) 3 : 0

Combustion

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

Santosh Hemchandra

Pre-requistes : None

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

AE 242 (JAN) 3 : 0

Aircraft Engines

Description of air breathing engines, propeller theory, engine propeller matching, piston engines, turbofan, turbo-prop, turbojet, component analysis,ramjets, velocity and altitude performance, thrust augmentation starting,principles of component design/selection and matching.

Sivakumar D

Pre-requistes : None

References : Zucrow, M.J., Aircraft and Missile Propulsion, Vols. I and II John Wiley, 1958.~Hill, P.G., and Peterson, C.R., Mechanics and Thermodynamics of Propulsion,Addison Wesley, 1965.~Shepherd, D.G., Aerospace Propulsion, American Elsevier Pub., 1972.

AE 243 (JAN) 3 : 0

Rocket Propulsion

Introduction to rocket engines, features of chemical rocket propulsion, rocket equation, thrust equation, quasi-one-dimensional nozzle flow, types of nozzles, thrust control and vectoring, aerothermochemistry, propellant chemistry,performance parameters, solid propellant rocket internal ballistics,components and motor design of solid propellant rockets, ignition transients,elements of liquid propellant rocket engines, and spacecraft propulsion.

Pratikash Prakash Panda

Pre-requistes : None

References : Sutton, G.P., Rocket Propulsion Elements, John Wiley and Sons, 2001. ~Barrare,M., et al., Rocket Propulsion, Elsevier Co., 1960.~Huzel, D.K., and Huang, D.K., Modern engineering for design of liquid-propellant rocket engines, AIAA, 1992.

AE 252 (JAN) 3 : 0

Analysis and Design of Composite Structures

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

Narayana Naik G

Pre-requistes : None

References : Gibson, R.F., Principles of Composite Material Mechanics, CRC Press, 2nd Edition, 2007.~Jones, R.M., Mechanics of Composite Materials, 2nd

AE 255 (AUG) 3 : 0

Aeroelasticity

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

Pre-requistes : None

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

AE 258 (JAN) 3 : 0

Non - Destructive Testing and Evaluation

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

Ramachandra Bhat M

Pre-requistes : None

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

AE 260 (JAN) 3 : 0

Modal Analysis: Theory and Applications

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

Siddanagouda Kandagal

Pre-requistes : None

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

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

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 264 (JAN) 3 : 0

Vibrations

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

Kartik Venkatraman

Pre-requistes : None

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

AE 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.

Pre-requistes : None

References : None

AE 299 (AUG) 0 : 20

Dissertation Project

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

Joseph Mathew

Pre-requistes : None

References : None

AE 372 (JAN) 3 : 0

Applied optimal Control and State Estimation

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

Radhakant Padhi

Pre-requistes : None

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

AE 297 (JAN) 0 : 1

Aerospace Seminar

Kartik Venkatraman

Pre-requistes : None

References : None

AE 292 (JAN) 3 : 0

Special topics in Aerospace Engineering 2

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

Ramesh O N

Pre-requistes : None

References : None

Atmospheric and Oceanic Sciences

Preface

AS 202 (JAN) 3 : 0

Geophysical Fluid Dynamics

Large-scale, slowly evolving flows on a rotating earth. Vorticity, potential vorticity (pv), consequences of pv conservation. Poincare, Kelvin and Rossby waves. Rotating shallow water equations, effects of stratification and the rotating-stratified Boussinesq equations. Quasi- geostrophic flow and pv,Rossby waves on the mid-latitude beta plane. Basic concepts of tropicaldynamics.Waves, jets and undercurrents on the equatorial beta plane. Waves and large-scale flow in the atmosphere and ocean from observations.

Jai Suhas Sukhatme

Pre-requistes : None

References : Pedlosky, J., Geophysical Fluid Dynamics, Springer Verlag, 1977,Gill, A.,Atmosphere and Ocean Dynamics, Academic Press Inc., 1982.,Holton,J.R., An Introduction to Dynamic Meteorology, Academic Press, 1992. Relevant Journal Articles

AS 203 (AUG) 3 : 0

Atmospheric Thermodynamics

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

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 204 (AUG) 3 : 0

Atmospheric Radiation and Climate

Black body radiation, properties of surfaces, Kirchoff’s law, radiative transfer in gases, solar radiation, terrestrial radiation, Rayleigh and Mie scattering, aerosols, vertical thermal structure, radiation budget, cloud forcing, and simple climate models.

Pre-requistes : None

References : None

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.

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

Pre-requistes : None

References : None

AS 208 (JAN) 3 : 0

Satellite Meteorology

Introduction to radiative transfer, radiative properties of surface, radiative properties of the atmosphere, scattering of radiation, image analysis. Thermal, infrared and microwave techniques for measurement of temperature, humidity and cloud height. Atmospheric sounders, limb sounding, radiation budget.

Satheesh S K

Pre-requistes : None

References : Kidder, S.Q., and Vonder Haar, T.R., Satellite Meteorology, Academic Press,1995,Houghton, J.T., Taylor, F.W., and Rodgers, C.D.,,Remote Sensing of Atmosphere, Cambridge Univ. Press, 1984

AS 210 (JAN) 3 : 0

Numerical methods in atmospheric modeling

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

Ashwin K Seshadri

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

References : A Chandrasekar, Numerical Methods for Atmospheric and Oceanic Sciences, Cambridge University Press, 2022

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

AS 211 (JAN) 2 : 1

Observational Techniques

Principles of measurement and error analysis, fundamentals of field measurements, in situ measurement of atmospheric temperature, humidity, pressure, wind, radiation, precipitation and aerosols. Tower based techniques and automatic measurement systems. Upper air observations, radiosonde techniques. Measurements in the ocean, CTD, ADCP and ARGO. Modern measurement techniques.

Bhat G S

Pre-requistes : None

References : Guide to Meteorological Measurements and Methods of Observation,,World Meteorological Organization Publication No. 8,,7th Edition, WMO, Geneva. radiative transfer, the role of radiation in climate.~Harrison R. G. Meteorological Measurements and Instrumentation Wiley, (2014)~DeFelice, T. P.,An Introduction to Meteorological Instrumentation and Measurement. Prentice Hall, 1998.

AS 313 (JAN) 3 : 0

Non-Linear Model in Climate Sciences

An introduction to nonlinear dynamics: linearization, bifurcation, chaos; Numerical methods in brief; Model reduction techniques; Derivation and analysis of low order models for the atmosphere, ocean, climate dynamics, and geophysics (e.g., Rayleigh-Bénard convection, vorticity, examples from general circulation, ocean thermohaline circulation, planetary dynamos, energy balance and global warming, ice sheets, ENSO, carbon cycle, examples from paleoclimate), observability and state estimation.

Ashwin K Seshadri

Pre-requistes : None

References :
A Provenzale and N Balmforth, Chaos and Structures in Geophysics and Astrophysics

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.

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 201 (JAN) 2 : 1

Introduction to Earth System Science

Role of topography and geology during interaction of Earth system processes;composition of Lithosphere, Atmosphere, Hydrosphere and Biosphere; Earth surface processes and its effect on earth systems, earth as a dynamic planet;Early atmosphere, evolution of atmosphere through time, evolution of hydrosphere and general circulation of ocean through time; Long and short term history of cryosphere; fossilization; Geochemical evidences documenting origin of life; extinction events, biosphere on land and ocean, Great oxygenation Event (GOE);Paleobiology; Microfossils; Indian climate present day and past;Global paleoclimatic record; Palaeo-monsoon record and the role of tectonics and green house forcing. Practical: Project on spatial and temporal evolution of earth system

Prosenjit Ghosh

Pre-requistes : None

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

ES 203 (JAN) 3 : 0

Introduction to Petrology

Theory: Rock forming minerals, textures of Igneous, metamorphic and sedimentary rocks, microtextures and reactions, using petrological datasets,rock types and tectonic settings, geothermometry and geobarometry, isochemical phase diagrams and its interpretations, linking petrology to geochronology,Geology of southern India and applications of petrology.

Sajeev Krishnan

Pre-requistes : None

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

ES 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.

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.

Pre-requistes : None

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

ES 207 (JAN) 0 : 3

Earth Science Laboratory

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

Binod Sreenivasan

Pre-requistes : None

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

ES 209 (AUG) 3 : 0

Biogeochemistry

Geochemistry of the lithosphere and hydrosphere, bio reactive elements, electronic structure of atoms, periodic tables, chemical bonds, Crystals, Ionic substitution, chemical and Isotope geothermometer, chemical precipitation and stability of minerals, acids and bases, salts and their ions, Thermodynamics, mineral stability, clay minerals, carbonate minerals, oxidation-reduction reaction, isotope fractionation, mixing and dilution, rate of chemical processes, chemical weathering, chemical composition of surface water, stable isotope geochemistry, Carbon cycling, other geochemical cycle (- P-N-S), Metabolism and geochemical index in biosystem, Mineral-Microbe- Interaction, Bio-weathering, Biomineralization.

Pre-requistes : None

References :
Schlesinger, W.H., Biogeochemistry: An analysis of Global Change, Academic Press, 1997~Faure, G., Principle and application of inorganic geochemistry,

ES 212 (JAN) 3 : 0

Fluid dynamics of planetary interiors

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

Binod Sreenivasan

Pre-requistes : None

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

ES 213 (JAN) 3 : 0

Isotope Geochemistry

Nuclear systematics; decay mode of radionuclides; radioactive decay; Rb- Sr, Sm-Nd, Lu-Hf, Re-Os and U-Th-Pb systematics, U series disequilibrium, stable isotope fractionation, early Solar System processes, crust-mantle processes, aquatic processes, selected mass spectrometry techniques.

Ramananda Chakrabarti

Pre-requistes : None

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

ES 215 (AUG) 3 : 0

Introduction to Chemical Oceanography

The concentration, isotopic composition, and distribution of the dissolved and particulate components of seawater tells the story of a fascinating and complex interplay between tectonic uplift, chemical and physical weathering, climate, biology, ocean circulation, and intrinsic properties of elements and ions in solution. In this series of lectures we will try to understand what controls the chemistry of seawater from a regional to global scale and what is the interplay between climate and ocean chemistry. The major themes that will be covered are: (a) concentration, spacio-temporal distribution, and the residence time 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

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 299 (JAN) 0 : 25

Dissertation Project

MTech thesis dissertation

Ramananda Chakrabarti

Pre-requistes : None

References : None

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

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

Pre-requistes : None

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

ES 219 (JAN) 3 : 0

Inverse Problems in Geophysics

An important aspect of geophysics is inversion, where we make inferences about physical parameters of the Earth from the recorded measurements. This course presents the mathematical formulation and design of inverse problems such as traveltime tomography, waveform inversion, surface wave tomography. Towards the end, emerging methods that use machine learning in geophysical inversion will also be discussed. A list of topics that are covered in this course: Linear Discrete Inverse Problems; The Least-Squares Problem; Preconditioning; Regularization; Non-linear Inverse Problems; Monte Carlo Methods; Probabilistic Inference; Examples of Linear and Non-linear Inverse Problems; Introducing Machine Learning for Inverse Problems.

Pawan Bharadwaj Pisupati

Pre-requistes : None

References : • Parameter Estimation and Inverse Problems, Richard Aster, Brian Borchers, Cliff Thurber • Inverse Problem Theory, Albert Tarantola • Geophysical Signal Analysis, Enders A. Robinson, Sven Treitel • Fundamentals of Geophysical Data Processing, John FClarebou

ES 220 (JAN) 3 : 0

Introduction to satellite Geodesy

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

Bramha Dutt Vishwakarma

Pre-requistes : None

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

Sustainable Technologies

Preface

ST 203 (AUG) 3 : 0

Design, Technology and Sustainability

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

Pre-requistes : None

References : None

ST 206 (JAN) 2 : 1

Environmental and Natural Resources Management

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

Ramachandra T V

Pre-requistes : None

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

ST 210 (AUG) 3 : 1

Principles and Applications of GIS and Remote Sensing

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

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.

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

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 213 (JAN) 3 : 0

Turbo machines in Renewable Energy

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

Punit Singh

Pre-requistes : None

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

ST 217 (AUG) 3 : 1

Field hydrology, river engineering and basin studies

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

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 219 (AUG) 3 : 0

Separation Technologies for Sustainable Industrial Processes

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

Pre-requistes : None

References :

[1] De Haan, André B., and Hans Bosch, ‘Industrial separation processes: fundamentals. Walter de Gruyter, 2013’.

ST 218 (JAN) 3 : 0

Sustainable Wastewater Management

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

Sreenivasan Ramaswami

Pre-requistes : None

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

ST 222 (JAN) 3 : 0

Basic Concepts of Planning and Design of Hydro-Mechanical Components in Dam

Introduction & Types of Gates: Brief history of development, Gates components, main applications, types and classification. Selection of Hydraulic Gates: Selection criteria of Hydraulic gates, operational requirement, present gate size & head limits Hydraulic Gates Design & Weight Estimation: Hydrostatic, load cases, allowable stresses, design of skin plate, horizontal beams, embedment, gate weight estimation Hydro-dynamic Forces: Hydro-dynamic forces (downpull, uplift, cavitation etc.), aeration, modelling,etc. Gate Operating Systems: Gate operating forces, hoists (Hydraulic & mechanical) Materials, Fabrication, Erection, Testing& Commissioning etc. Materials, rubber seals, fabrication, transportation & erection materials, fabrication transportation, erection, testing & commissioning. Hydraulic Gates for Dam Safety: Operation & maintenance of hydraulic Gates, rehabilitation, inspection, operation & maintenance, automation, etc. Recent trends & developments in Hydraulic gates engine.

Punit Singh

Pre-requistes : None

References : 1)Design of Small Dams-A Water Resources Technical Publication, United States Department of The Interior, Bureau of Reclamation, Third edition - 1987 2)Bandyopadhyay, Jayanta ‘Restoration of Ecological Status of Himalayan Rivers in China and India: the Case of the Two Mother Rivers – the Yellow and the Ganges’ in Shikui Dong, Jayanta Bandyopadhyay and Sanjay Chaturvedi (Eds)

ST 221 (JAN) 3 : 0

Concrete Technology: fundamentals and sustainable practices

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

Souradeep Gupta

Pre-requistes : None

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

ST 223 (JAN) 3 : 0

Green Catalysis in Chemical Industries

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

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

Navneet Kumar Gupta

Pre-requistes : None

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

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:

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.

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:

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.

Pre-requistes : None

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

CH 205 (JAN) 3 : 0

Chemical Reaction Engineering

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

Venugopal S

Pre-requistes : None

References : •Ming, D., Glasser, D., Hildebrandt, D., Glasser, B., and Metzger, M., http://attainableregions.com/ – An Introduction to Choosing an Optimal Reactor •Levenspiel, O., Chemical Reactor Omnibook •Stewart, W. E., and Caracotsisos, M., Computer-Aided Modeling of Reactive Systems • Mory, M., Fluid Mechanics for ChemicalEngineering • Fogler.,http://umich.edu/~elements/5e/index.html

CH 206 (AUG) 1 : 0

Seminar Course

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

Pre-requistes : None

References : None

CH 207 (JAN) 1 : 0

Applied statistics and design of experiments

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

Venugopal S

Pre-requistes : None

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

CH 235 (AUG) 3 : 0

Modeling in Chemical Engineering

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

Pre-requistes : None

References : Lecture notes

CH 236 (JAN) 3 : 0

Statistical Thermodynamics

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

Ganapathy Ayappa

Pre-requistes : None

References :
McQuarrie, D.A., Statistical Mechanics, Viva Books, 2003.~Hill, T. L., An Introduction to Statistical Thermodynamics, Dover Publications, 1986.

CH 248 (JAN) 3 : 0

Molecular Systems Biology

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

Rahul Roy

Pre-requistes : None

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

CH 241 (AUG) 3 : 0

Nanotechnology

CH241 Nanotechnology (3:0)
Introduction to Chemical Engineering Perspective of Nanotechnology, Physics and Chemistry at the nanoscale, Overview of Characterization methods, Overview of Fabrication techniques, Functional nanostructured materials, Critical review of current applications of nanotechnology in catalysis for energy transition

Pre-requistes : Bachelors Degree in Chemical Engineering

References : G. Timp (Ed.), Nanotechnology, Springer International Edition, 2005.

J. Lambauer, A. Voss, and U. Fahl, Nanotechnology and Energy-

CH 246 (AUG) 3 : 0

Advanced Process Control

Pre-requistes : None

References : None

CH 299 (JAN) 0 : 32

Dissertation Project

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

Sudeep Punnathanam

Pre-requistes : None

References : None

CH 250 (JAN) 3 : 0

Laminar flows

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

Kumaran V

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

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

CH 251 (JAN) 3 : 0

Machine Learning for Materials and Molecules

Introduction to data science and machine learning, supervised and unsupervised learning, regression and classification problems, motivation behind modeling materials and molecules with examples from sustainable energy conversion, clean water/air, and human health; introduction to Python, scientific computing packages (NumPy, SciPy, Matplotlib), and simple ML packages (Scikit-learn, RDKit, DeepChem); linear and nonlinear regression, confidence intervals and goodness of fit, loss functions, gradient descent algorithm, overfitting/ underfitting, regression/classification learning; clustering, singular-value decomposition, and principal component analysis; decision trees and ensemble methods, boosting and bagging techniques, random forests, gradient-boosted machine learning, hyperparameter tuning; introduction to neural networks and deep learning; principles of data generation using molecular dynamics (MD), Monte Carlo (MC), and density functional theory (DFT) simulations with examples from computational catalysis and batteries; cheminformatics, graph and featurized representations of materials, molecules, and nanopores, and their applications in materials/molecular discovery; application of machine learning in predicting molecular/materials properties

Ananth Govind Rajan

Pre-requistes : CH 201 (Engineering Mathematics) or CH 202 (Numerical Methods) or any equivalent course

References : 1. Hastie, T., Tibshirani, R., Friedman, J. H., & Friedman, J. H. (2009). The Elements of Statistical Learning: Data Mining, Inference, and Prediction (Vol. 2, pp. 1-758). New York: Springer.

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.

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

Pre-requistes : None

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

CE 202 (JAN) 3 : 0

Foundation Engineering

Subsurface investigations. Bearing capacity of shallow foundations, penetration tests, plate load tests. Settlement of shallow foundations, elastic and consolidation settlements; settlement, estimates from penetration tests, settlement tolerance. Allowable bearing pressure. Foundations on problematic soils. Principles of foundation design. Introduction of deep foundations. Bearing capacity and settlement of piles and pile groups in soils.Machine foundations.

Tejas Gorur Murthy

Pre-requistes : None

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

CE 203 (JAN) 3 : 0

Surface Water Hydrology

Review of basic hydrology, hydrometeorology, infiltration, evapotranspiration, runoff and hydrograph analysis. Flood routing – lumped, distributed and dynamic approaches, hydrologic statistics, frequency analysis and probability,introduction to environmental hydrology, urban hydrology.Design issues in hydrology.

Mujumdar P P

Pre-requistes : None

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

CE 204 (AUG) 3 : 0

Solid Mechanics

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

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 205 (AUG) 3 : 0

Finite Element Method

Concepts of the stiffness method. Energy principles. Continuum BVP and their integral formulation. Variational methods: Raleigh-Ritz, weighted residual methods, virtual work and weak formulations. Finite element formulation of one, two and three dimensional problems, Isoparametric formulation. Computational aspects and applications, Introduction to non-linear problems.

Pre-requistes : None

References : Zienkiewicz, O.C. and Taylor, R.L., The Finite Element Method: Vol. 1 (The Basis), Butterworth-Heinemann, 2000.~Cook R.D.. Malkus, D. S., Plesha and Witt, R.J., Concepts and Applications of Finite Element Analysis, Fourth edition,John Wiley and Sons.~J N Reddy, An Introduction to the Finite Element Method,Second Edition, McGraw Hill Inc, 1993.

CE 207 (JAN) 3 : 0

Geo-environmental Engineering

Sources, production and classification of wastes, Environmental laws and regulations, physico-chemical properties of soil, ground water flow and contaminant transport, contaminated site characterization, estimation of landfill quantities, landfill site location, design of various landfill components such as liners, covers, leachate collection and removal, gas generation and management, ground water monitoring, end uses of landfill sites, slurry walls and barrier systems, design and construction, stability,compatibility and performance, remediation technologies, stabilization of contaminated soils and risk assessment approaches.

Sivakumar Babu G L

Pre-requistes : None

References : Sharma, H.D., and Reddy, K.R., Geoenvironmental Engineering: Site Remediation, Waste Containment and Emerging Waste Management Technologies, John Wiley & Sons, Inc., Hoboken, New Jersey, 2004.~Rowe, R. Kerry, Quigley, Robert M.,Brachman, Richard W. I., and Booker, John R. Barrier Systems for Waste Disposal Facilities , 2nd edn 2004. Spon Press, Taylor & Francis Group,

CE 208 (JAN) 3 : 0

Ground Improvement and Geosynthetics

Principles of ground improvement, mechanical modification. Properties of compacted soil. Hydraulic modification, dewatering systems, preloading and vertical drains, electro-kinetic dewatering, chemical modification, modification by admixtures, stabilization using industrial wastes, grouting, soil reinforcement principles, properties of geo-synthetics, applications of geo-synthetics in bearing capacity improvement, slope stability, retaining walls, embankments on soft soil, and pavements. filtration, drainage and seepage control with geo-synthetics, geo- synthetics in landfills, soil nailing and other applications of geo- synthetics.

Gali Madhavi Latha

Pre-requistes : None

References : Hausmann, M.R., Engineering Principles of Ground Modification, McGraw- Hill, 1990.~Jones, C.J.E.P., Reinforcement and Soil Structures, Butterworth Publications, 1996.~Koerner, R. M., Designing with Geosynthetics, Prentice Hall Inc. 1998.Dover Publications, New York~

CE 209 (JAN) 3 : 0

Mechanics of Structural Concrete

Introduction, Limit state design philosophy of reinforced concrete, Stress-strain behavior in multi-axial loading, failure theories, plasticity and fracture, ductility, deflections, creep and shrinkage, Strength of RC elements in axial, flexure, shear and torsion, RC columns under axial and eccentric loading, Beam-column joints, Strut and Tie modelling, Yield line theory of slabs, Seismic resistant design, Methods for predicting the behavior of pre-stressed concrete members and structures.

Ananth Ramaswamy

Pre-requistes : None

References : Nilson, A. H., Darwin, D. and Dolan, C. W., Design of concrete structures,McGraw Hill, 2004~ Lin and Burns, Design of Prestressed concrete structures,John Wiley and Sons, 2006~ Agarwal and Shrikhande- Earthquake resistant design of structures, Prentice-Hall of India Pvt. Ltd. New Delhi, 2006.

CE 210 (JAN) 3 : 0

Structural Dynamics

Equations of motion. Degrees of freedom. D' Alembert principle. SDOF approximation to vibrating systems. Energy storage elements: mass, stiffness and damper. Undamped free vibration. Natural frequency. Damped free vibration. Critical damping. Forced response under periodic and aperiodic excitations.Support motions. Resonance. Impulse response and complex frequency response functions. Duhamel integral. Vibration isolation: FTR and DTR. Multi-DOF systems. Normal modes and natural frequencies. Orthogonality of normal modes. Natural coordinates. Uncoupling of equations of motion. Repeated natural frequencies. Proportional and non proportional damping. Damped normal modes. Principle of vibration absorber. Continuous systems. Vibration of beams. Forced response analysis by eigenfunction expansion. Moving loads and support motions. Effect of axial loads. Approximate methods for vibration analysis. Rayleigh's quotient. Rayleigh-Ritz method. Method of weighted residual. Method of collocation.

Manohar C S

Pre-requistes : None

References : Meirovich, L., 1984, Elements of vibration analysis, McGraw-Hill, NY~Clough R W and J Penzien, 1993, Dynamics of structures, McGraw-Hill, NY~Rao,S S 2004,Mechanical Vibrations, 4th Edition, Pearson Education, New Delhi.

CE 211 (AUG) 3 : 0

Mathematics for Engineers

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

Pre-requistes : None

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

CE 214 (JAN) 3 : 0

Ground Water Hydrology

Ground water and hydrological cycle. Ground water movement and balance. Ground water monitoring. Equations of flow. Well hydraulics - analysis of aquifer tests and models. Regional groundwater resource evaluation and numerical modeling. Groundwater recharge estimation. Base flow analysis and models.Ground water quality. Mass transport in ground water. Tracer tests and scale effects of dispersion. Solute transport modeling.

Sekhar M

Pre-requistes : None

References : Freeze,A. R. and Cherry,J. A. Groundwater,Prentice Hall,1979.~Fetter, C. W.Applied Hydrogeology, Prentice Hall, 1988.~Domenico, P. A., and Schwartz, F. W. Physical and Chemical Hydrogeology, John Wiley, 1990. Fetter, C. W.Contaminant Hydrogeology, Prentice Hall, 1993.

CE 215 (JAN) 3 : 0

Stochastic Hydrology

Introduction to random variables, statistical properties of random variables.Commonly used probability distributions in hydrology. Fitting probabilitydistributions to hydrologic data. Probability plotting and frequency analysis.Data generation. Modeling of hydrologic uncertainty - purely stochastic models, first order Markov processes. Analysis of hydrologic time series - autocorrelation and spectral density functions. Applications to hydrologic forecasting.

Srinivas V V

Pre-requistes : None

References : Bras, R.L. and Rodriguez-Iturbe, Random Functions and Hydrology, Dover Publications, New York, USA, 1993.~Hann, C.T., Statistical Methods in Hydrology, First East-West Press Edition, New Delhi, 1995.~Ang, A.H.S. andTang, W.H.,Probabilistic concepts in Engineering Planning Design, Vol. 1,Wiley, New York, 1975.~Clarke, R.T., Statistical Models in Hydrology, John Wiley, Chinchester, 1994

CE 220 (AUG) 3 : 0

Design of Substructures

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

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

Pre-requistes : None

References :
Geotechnical Earthquake Engineering By Steven L. Kramer, Pearson Education,2003~Geotechnical Earthquake Engineering Handbook, Robert W.

CE 226 (AUG) 3 : 0

Open-channel Flow

Basic Concepts of Fluid Mechanics Introduction to Open-channel Flow Uniform Flow Non-uniform Flow: Gradually Varied Non-uniform Flow: Rapidly Varied Spatially Varied Flow Unsteady Flow Pollutant Transport in Open Channels

Pre-requistes : None

References : Te Chow, Ven. Open-channel hydraulics. Vol. 1. New York: McGraw-Hill, 1959.~Chaudhry, M. Hanif. Open-channel flow. Springer Science & Business Media,2007.~Srivastava, Rajesh. Flow through open channels. Oxford Higher Education,2008.

CE 227 (JAN) 3 : 0

Engineering Seismology

Introduction to earthquake hazards. Strong ground motions,tsunamis, landslides, liquefaction. Overview of plate tectonics and earthquake source mechanisms. Theory of wave propagation. Body waves and surface waves. Concepts of seismic magnitudes and intensity.Seismic station. Sensors and data loggers,mechanical and digital sensors. Interpretation of seismic records – acceleration, velocity and displacement. Regional seismicity and earthquakes in India.Seismic zonation – scales, macro and micro,attenuation, recurrence relation.Seismic hazard analysis - deterministic and probabilistic.Site characterization – different methods and experiments. Local site effects,ground motion amplifications. Development of response/design spectrum. Liquefaction hazard assessments. Integration of hazards using GIS. risk and vulnerability Studies.

Anbazhagan P

Pre-requistes : None

References : Earthquake Engineering – From Engineering Seismology to Performance Based Engineering,Edited by Bozorgnia,Y.and Bertero,V.V.,CRC Press Washington 2004.

CE 228 (JAN) 3 : 0

Introduction to the Theory of Plasticity

1D plasticity and visco-plasticity; physical basis of plasticity; uniaxial tensile test & Bauschinger effect; structure of phenomenological plasticity theories; internal variables; yield criteria (Tresca, von Mises, Mohr-Coulomb,Drucker-Prager); geometry of yield surfaces; Levy-Mises equations; flow rules;plastic/ viscoplastic potentials; consistency condition; isotropic and kinematic hardening; Drucker's postulate; Principle of maximum plastic dissipation; associativity; convexity; normality; uniqueness; selected elastic- plastic boundary value problems (tension and torsion of tubes and rods, pressurized thin and thick spherical shells); collapse; advanced hardening models; introduction to computational plasticity; integration of plasticity models; return mapping; principle of virtual work; Finite elements for plasticity

Narayan K Sundaram

Pre-requistes : None

References : None

CE 229 (JAN) 3 : 0

Non-Destructive Evaluation Methods for Concrete Structures

Planning and interpretation of in-situ testing of concrete structures; Surface hardness methods; Fundamental bases and methodologies of non- destructive evaluation (NDE) techniques related to concrete structures; NDE methods for concrete testing based on sounding: Acoustic emission (AE) testing of concrete structures; NDE methods for concrete testing ased on sounding: Ultrasonic pulse velocity (UPV) methods; Partially destructive strength tests related to concrete; cores; Examples of UPV corrections for reinforcement;examples of evaluation of core results

Remalli Vidya Sagar

Pre-requistes : None

References : J. H. Bungey and S. G. Millard (1996) Testing of concrete in structures. Blackie Academic & Professional, 1996, chapman & Hall publishers.~V. M. Malhotra and N. J. Carino (2005) Handbook on Nondestructive Testing of Concrete Ed. by V.M. Malhotra and N.J. Carino., CRC publishers.~C. V. Subramanian (2016) Practical Ultrasonics., Narosa publishers~C. U. Gross and M. Ohtsu (2008) Acoustic

CE 235 (JAN) 3 : 0

Optimization Methods

Basic concepts, Kuhn-Tucker conditions, linear and nonlinear programming,treatment of discrete variables, stochastic programming, Genetic algorithm,simulated annealing, Ant Colony and Particle Swarm Optimization, Evolutionary algorithms, Applications to various engineering problems.

Debraj Ghosh

Pre-requistes : None

References : Arora, J.S. Introduction to Optimization, McGraw-Hill (Int. edition) 1989.~Rao,S.S., Optimization: Theory and Applications. Wiley Eastern, 1992 ~Current Literature.

CE 236 (AUG) 3 : 0

Fracture Mechanics

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

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

Pre-requistes : None

References : None

CE 249 (AUG) 3 : 0

Water Quality Modeling

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

Pre-requistes : None

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

CE 262 (JAN) 3 : 0

Public Transportation Systems Planning

Modes of public transportation and application of each to urban travel needs;comparison of transit modes and selection of technology for transit service;transit planning, estimating demand in transit planning studies, demand modeling, development of generalized cost, RP & SP data and analysis techniques; functional design and costing of transit routes, models for planning of transit routes, scheduling; management and operations of transit systems; integrated public transport planning; operational, institutional, and physical integration; models for integrated planning; case studies.

Tarun Rambha

Pre-requistes : None

References : A. Verma and T. V. Ramanayya, Public Transport Planning and Management in Developing Countries, CRC Press, 2014~VuchicVukan R., Urban Transit: Operations, Planning and Economics, Prentice Hall, 2005~Gray G. E., and Hoel L. A., Public Transportation, Prentice Hall, 1992.

CE 272 (JAN) 3 : 0

Traffic Network Equilibrium

Traffic assignment; Fixed points and Variational inequalities; Fundamentals of convex optimization; Shortest path algorithms; Wardrop user equilibrium;System optimum and Price of Anarchy; Link-based algorithms (Method of successive averages, Frank-Wolfe); Potential games; Variants of the traffic assignment problem (Multiple-classes, Elastic demand); Path-based algorithms;Origin-based methods; Sensitivity analysis.

Tarun Rambha

Pre-requistes : None

References : Sheffi, Y. Urban Transportation Networks: Equilibrium Analysis with Mathematical Programming Methods. Prentice Hall, 1985.~Patriksson, M. The traffic assignment problem: models and methods. Courier Dover Publications, 2015.

CE 277 (JAN) 3 : 0

Remote Sensing in Ecohydrology

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

Debsunder Dutta

Pre-requistes : None

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

CE 279 (JAN) 3 : 0

Computational Geotechnics

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

Swetha Veeraraghavan

Pre-requistes : None

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

CE 299 (JAN) 0 : 22

Project

The project work is aimed at training the students to analyze independently problems in geotechnical engineering, water resources engineering, structural engineering and transportation and infrastructural engineering. The nature of the project could be analytical, computational, experimental, or a combination of the three. The project report is expected to show clarity of thought and expression, critical appreciation of the existing literature, and analytical,computational, experimental aptitudes of the student.

Debraj Ghosh

Pre-requistes : None

References : None

CE 213 (JAN) 3 : 0

Systems Techniques in Water Resources Engineering

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

Nagesh Kumar D

Pre-requistes : None

References : Loucks, D.P., Stedinger, J.R. and Haith, D.A., Water Resources Systems Planning and Analysis, Prentice Hall, Englewood Cliffs, N.J, 1981. ~Vedula, S. and Mujumdar, P. P., Water Resources Systems: Modelling Techniques Tata-McGraw Hill, 2005.~Srinivasa Raju, K and Nagesh Kumar, D., Multicriterion Analysis in Engineering and Management, PHI Ltd., New Delhi, 2010.

CE 217 (AUG) 3 : 0

Fluid Mechanics

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

Pre-requistes : None

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

CE 271 (JAN) 3 : 0

Choice Modeling

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

Abdul Rawoof Pinjari

Pre-requistes : None

References : F. Koppelman & C.R. Bhat. A Self-Instructing Course in Mode Choice Modeling: Multinomial and Nested Logit Models, 2006.~K. Train. Discrete Choice Methods with Simulation (2nd edition),Cambridge University Press, 2009.~M. Ben-Akiva & S.R. Lerman. Discrete Choice Analysis: Theory and Application to Travel Demand, MIT Press, 1985.

CE 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.

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 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.

Pre-requistes : None

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

CE 295 (JAN) 3 : 0

Earth Retaining Structures and Earthen Dams

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

Jyant Kumar

Pre-requistes : None

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

CE 286 (JAN) 3 : 0

Sediment Management in Reservoirs

Introduction to Sediment Management; Magnitude of the Problem Erosion and Sedimentation in Drainage Basins: Weathering Processes, Erosion, Sediment Delivery Ratio, Rates of Erosion and Delivery, Human Impact on Sediment Yield, Impact of Natural Events, Measurement of Sediment Load Reservoir Sedimentation Process: Hydrological and Hydraulic Processes, Erosion, Transport and Sedimentation, Sources and Processes, Morphological Processes, Sediment Size, Entrainment, Suspension, Suspended Material Load, Bed Material Load, Unit Weight of Deposits, Delta Formation Predictive Methods for Reservoir Sedimentation: Measurement and Monitoring Techniques, Empirical andAnalytical Methods, Physical Modelling, Satellite, UAV and USV, Post-Processing and Analysis Tools for Topo-Bathymetric Data, Computational Modelling Mitigation of Reservoir Siltation: Erosion and Sedimentation Control, Sediment Routing, Structural and Non-Structural Adaptive Measures, Watershed Management, Check Dams, Sediment Bypassing, Sediment Flushing, Sediment Sluicing, Density Currents, Sediment Dredging, Sediment disposal and beneficial use. Reservoir Sedimentation in India: National Records and Regulation of Dams in India, Indian Standard Code, Guidelines and Compendium on Reservoir Sedimentation, Reservoir Sediment Management in India, Sedimentation Data and Observation in Selected Reservoirs, Sediment Management in Indian Reservoirs: Good Practices and Problems. Case Studies.

Nanjunda Rao K S , Sekhar M

Pre-requistes : None

References : 1. Handbook for Assessing and Managing Reservoir Sedimentation (CWC, February 2019). 2. Morris, G. L. and Fan, J. 1998. Reservoir Sedimentation Handbook, McGraw-Hill Book Co., New York. 3. Graf, W. H. (1971). Hydraulics of Sediment Transport. McGraw-Hill Book Co., New York. 4. Dey, S. (2014). Fluvial Hydrodynamics: Hydrodynamic and Sediment Transport Phenomena.

CE 285 (JAN) 3 : 0

Disaster Management for Dams

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

Nagesh Kumar D , Srinivas V V

Pre-requistes : None

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

CE 205A (AUG) 3 : 1

Transportation Logistics

Solution methods for integer programs (Branch and bound, Cutting plane algorithms, Branch and price); Travelling Salesman Problem; Vehicle Routing Problem and variants; Shared ride systems; Crew scheduling; Facility location; Complexity theory; Collaborative logistics; Neighbourhood search; Heuristics

Pre-requistes :
Graduate level course on optimization/linear programming. Experience programming in Python.
References : Wolsey, L. A. (2020). Integer programming. John Wiley & Sons.
Toth, P., & Vigo, D. (Eds.). (2002). The vehicle routing problem. Society for Industrial and Applied Mathematics (SIAM).
Applegate, D. L. (2006). The traveling salesman problem: a computational study. Princeton university press.

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.

Pre-requistes : None

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

CE 201A (AUG) 3 : 0

Dam safety surveillance, instrumentation and monitoring

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

Pre-requistes : None

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

CE 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.

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.

CE 206A (JAN) 3 : 0

Mathematical methods for machine learning

Role of matrix algebra, optimization, probability, and statistics in developing ML tools. Vector and matrix norms. SVD and low rank approximations. PCA. Opimization concepts. Convexity. Gradient and stochastic gradient search. Multivariate random variables. Exponential family. Non-Gaussian models: ICA and copulas. Bayes theorem. Markov chains and MCMC samplers. Estimation theory. Sampling distributions. MLE and MAP. Regulairization: ridge and LASSO. Linear and logistic regression. Clustering. Support vector machines. Deep neural networks: cost functions. Markov decision theory and reinforcement learning. Kriging. Physics assisted learning. Analysis of dynamic state space models.

Manohar C S

Pre-requistes :
CE 211 (Mathemtical methods for engineers) or equivalent

References : K Murphy, 2022, Probabilistic machine learning: an introduction, MIT Press, Cambridge.
G Strang, 2019, Linear algebra and learning from data, MIT Press, Cambridge.
S L Brunton and N Kutz, 2022, Data-driven science and engineering: machine learning, dynamical systems and control, Cambridge

Climate Change

Preface

Materials Engineering

Preface

MT 201 (JAN) 3 : 0

Phase Transformations

Overview of phase transformations, nucleation and growth theories, coarsening,precipitation, spinodal decomposition, eutectoid, massive, disorder-to-order,martensitic transformations. crystal interfaces and microstructure. topics in the theory of phase transformations: linear stability analysis, elastic stress effects, sharp interface and diffuse interface models of microstructural evolution.

Chandan Srivastava

Pre-requistes : None

References : None

MT 202 (AUG) 3 : 0

Thermodynamics and Kinetics

Classical and statistical thermodynamics, Interstitial and substitutionalsolid solutions, solution models, phase diagrams, stability criteria, critical phenomena, disorder-to-order transformations and ordered alloys, ternary alloys and phase diagrams, Thermodynamics of point defects, surfaces and interfaces. Diffusion, fluid flow and heat transfer.

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.

Pre-requistes : None

References : M. Hatherly and W. B. Hutchinson, An Introduction to Texture in Metals (Monograph No. 5), The Institute of Metals, London~V. Randle, and O. Engler,Introduction to Texture Analysis: Macrotexture, Microtexture and Orientation mapping, Gordon and Breach Science Publishers~F. J. Humphreys and M. Hatherly,Recrystallization and Related Phenomenon, Pergamon Press~P. E. J.

MT 208 (JAN) 3 : 0

Diffusion in Solids

Aloke Paul

Pre-requistes : None

References : Paul G. Shewmon, Diffusion in Solids,A. Paul, T. Laurila, V. Vuorinen, S. Divinski, Thermodynamics, Diffusion and The Kirkendall effect in Solids,A. Paul, S. Divinski, Handbook of Solid State Diffusion

MT 209 (AUG) 3 : 0

Defects in Materials

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

Pre-requistes : None

References : W.D. Kingery, H.K. Bowen and D.R. Uhlmann: Introduction to Ceramics, 2nd ed.,John Wiley and Sons, 1976~D. Hull and D. J. Bacon: Introduction to dislocations, 4th ed., Butterworth-Heinemann, 2001.~D.A. Porter and K.E. Easterling: Phase Transformation in Metals and Alloys, 2nd ed. Chapman and Hall, 1992.~R.W. Balluffi, S.M. Allen, W.C. Carter: Kinetics of Materials, 1st ed. Wiley-

MT 213 (AUG) 3 : 0

Electronic Properties of Materials

Introduction to electronic properties; Drude model, its success and failure;energy bands in crystals; density of states; electrical conduction in metals;semiconductors; semiconductor devices; p-n junctions, LEDs, transistors;electrical properties of polymers, ceramics, metal oxides, amorphous semiconductors; dielectric and ferroelectrics; polarization theories; optical,magnetic and thermal properties of materials; application of electronic materials: microelectronics, optoelectronics and magnetoelectrics.

Pre-requistes : None

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

MT 218 (JAN) 2 : 1

Modeling and Simulation in Materials Engineering

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

Govind S Gupta , Aloke Paul , Chandan Srivastava , Suryasarathi Bose , Abhik N Choudhury , Sai Gautam Gopalakrishnan , Vikram Jayaram

Pre-requistes : None

References : A.B. Shiflet and G.W. Shiflet: Introduction to Computational Science: Modeling and Simulation for the Sciences, Princeton University Press, 2006.~D.C.Rapaport: The Art of Molecular Dynamics Simulation, Cambridge Univ. Press,1995.~K. Binder, D. W. Heermann: Monte Carlo Simulation in Statistical Physics, Springer, 1997.~K.G.F Janssens, D. Raabe, E. Kozeschnik, M.A. Miodownik,

MT 220 (JAN) 3 : 0

Microstructural Engineering of Structural Materials

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

Surendra Kumar Makineni

Pre-requistes : None

References : None

MT 225 (AUG) 3 : 0

Deformation and Failure Mechanisms at Elevated Temperatures

Phenomenology of Creep, Microstructural considerations in metals, alloys,ceramics and composites. Creep mechanisms, Deformation mechanism maps,Superpasticity in metal alloys, ceramics and nanophase materials, Commercial applications and considerations, Cavitation failure at elevated temperatures by nucleation, growth and interlinkage of cavities. The course will also include some laboratory demonstrations of the phenomena discussed in the class together with an appropriate analysis of the data.

Pre-requistes : None

References : None

MT 231 (AUG) 3 : 0

Interfacial Phenomena in Materials Processing

Pre-requistes : None

References : None

MT 241 (JAN) 3 : 0

Structure and Characterization

Bonding and crystal structures, Stereographic projection, Point and space groups, Defects in crystals, Schottky and Frenkel defects, Charged defects, Vacancies and interstitials in non stoichiometric crystals, Basics of diffraction theory, X-ray powder diffraction and its applications, Electron diffraction and Electron microscopy.

Rajeev Ranjan

Pre-requistes : None

References : A. R. West: Solid State Chemistry and its Applications, John Wiley~B. D. Cullity: Elements of x-ray Diffraction~A. Kelly and G. W. Groves: Crystallography and Crystal Defects, Longman~M. D. Graef and M. E. Henry:Structures of Materials, Cambridge~R. J. D. Tilley: Defects in Solids, Wiley 2008

MT 243 (AUG) 0 : 2

Laboratory Experiments in Materials Engineering

Experiments in Metallographic techniques, heat treatment, diffraction mineral beneficiation, chemical and process metallurgy, and mechanical metallurgy.

Rajeev Ranjan

Pre-requistes : None

References : None

MT 248 (JAN) 3 : 0

Modelling and Computational Methods in Metallurgy

Basic principles of physical and mathematical modelling. Similarity criteria and dimensional analysis. Detailed study of modelling of various metallurgical processes such as blast furnace, induction furnace, ladle steelmaking, rolling, carburizing and drying. Finite difference method. Solution of differential equations using various numerical techniques. Convergence and stability criteria. Assignments will be based on developing computer code to solve the given problem. Prerequisite: Knowledge of transport phenomena, program language

Govind S Gupta

Pre-requistes : None

References : Govind S Gupta,J.Szekely and N. J. Themelis: Rate Phenomena in Process Metallurgy, Wiley, New York, 1971,B. Carnahan, H. A. Luther, and J. O. Wikes:Applied Numerical Methods, John Wiley, NY 1969.

MT 250 (AUG) 3 : 0

Introduction to Materials Science and Engineering

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.

Pre-requistes : None

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

MT 255 (JAN) 3 : 0

Solidification Processing

Advantage of solidification route to manufacturing, the basics of solidification including fluid dynamics, solidification dynamics and the influence of mould in the process of casting. Origin of shrinkage, linear contraction and casting defects in the design and manufacturing of casting,continuous casting, Semi-solid processing including pressure casting, stir casting and thixo casting. Welding as a special form of manufacturing process involving solidification. Modern techniques of welding, the classification of different weld zones, their origin and the influence on properties and weld design. Physical and computer modeling of solidification processes and development of expert systems. New developments and their possible impact on the manufacturing technology in the future with particular reference to the processes adaptable to the flexible manufacturing system.

Abhik N Choudhury

Pre-requistes : None

References : Abhik N Choudhury,J. Campbell: Casting, Butterworth - Haneman, London, 1993,M.C. Flemings: Solidification Processing , McGraw Hill, 1974.

MT 256 (JAN) 3 : 0

Fracture

Review of elastic and plastic deformation. Historical development of fracture mechanics. Thermodynamics of fracture including Griffith theory. Linear elastic fracture mechanics. Irwin and Dugdale extensions. Stability of cracks.Crack resistance curves and toughening of brittle materials. Ductile failure. J-integral. Indentation failure. Environmental aspects of failure. Cyclic Fatigue. Methods to measure toughness. Fracture in thin films and interfaces. Toughening in hierarchical structures

Vikram Jayaram

Pre-requistes : None

References : B.R. Lawn: Fracture of Brittle Solids. Cambridge University Press (1993).,T.H.Courtney: Mechanical Behaviour of Materials. McGraw Hill (1990).,David Broek:Engineering Fracture Mechanics. . Sijthoff and Nordhoff , The Netherlands (1978).,Richard Hertzberg: Deformation & Fracture of Engineering Materials.John Wiley (1996).

MT 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.

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.

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 262 (JAN) 3 : 0

Concepts in Polymer Blends and Nanocomposites

Introduction to polymer blends and composites, nanostructured materials and nanocomposites, Polymer-polymer miscibility, factors governing miscibility,immiscible systems and phase separation, Importance of interface on the property development, compatibilizers and compatibilization, Blends of amorphous & semi-crystalline polymers, rubber toughened polymers, particulate,fiber reinforced composites. Nanostructured materials like nano clay, carbon nanotubes, graphene etc. and polymer nanocomposites. Surface treatment of the reinforcing materials and interface/interphase structures of composites nanocomposites. Various processing techniques like solution mixing, melt processing. Unique properties of blends, composites nanocomposites in rheological, mechanical, and physical properties and applications

Suryasarathi Bose

Pre-requistes : None

References : D.R. Paul and S. Newman: Polymer Blends, Vol 1&2 , Academic Press, 2000,L.A.Utracki: Polymer Alloys and Blends, Hanser, 2000,C. Chung: Introduction to Composites, Technomic, Lancaster, PA. 1998.,J. Summerscales and D. Short:Fiber Reinforced Polymers, Technomic. 1988,T.J. Pinnavia and G.W. Beall (Editors): Polymer-Clay Nanocomposites, Wiley, New York 2000. P.M. Ajayan,

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;

Pre-requistes : None

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

MT 299 (AUG) 0 : 32

Dissertation Project

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

Govind S Gupta

Pre-requistes : None

References : None

MT 245 (AUG) 3 : 0

Transport Processes in Process Metallurgy

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

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.

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

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 207 (AUG) 2 : 0

Introduction to electronic properties of Materials

Drude model, its success and failure, energy bands in crystals, basic quantum mechanics, band diagrams, Fermi function, density of states, molecular orbital theory, electrical conduction in metals, semiconductors, metal oxides, amorphous semiconductors, introduction to polarization theories, magnetism and superconductivity.

Pre-requistes : None

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

MT 309 (JAN) 3 : 0

Introduction to Manufacturing Science

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

Prosenjit Das

Pre-requistes : None

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

MT 307 (JAN) 3 : 0

Materials in Extreme environments

Overview of engineering systems under extreme environment

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

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

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

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

Ankur Chauhan

Pre-requistes : None

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

MT 308 (JAN) 3 : 0

Metal Forming Processes

[1]. Stress and strain
Lecture 1 - Stress at a point, stress tensor, force equilibrium, plane stress transformation, Mohr's circle for plane stress transformation
Lecture 2 - Strain, 2D or plane strain tensor, strain transformation equation
Lecture 3 - Isotropic elasticity, elastic work (strain energy)
[2]. Macroscopic plasticity and yield criteria
Lecture 4 - Tresca and Mises yield criteria
Lecture 5 - Plastic work, effective stress, effective strain
Lecture 6 - Flow rules (plastic stress strain relationships), normality principle
[3]. Work Hardening
Lecture 7 - Uniaxial tensile test, mechanical properties, elastic-plastic transition, engineering and true stress-strain curves
Lecture 8 - Power law, necking in a tensile test, direct compression, bulge test, plane stress compression test and torsion
[4]. Plastic instability
Lecture 9 - Instability in uniaxial and biaxial tension, instability of thin walled sphere and tubes, significance of instability
Lecture 10 - Effect of material inhomogeneity on uniform strain
[5]. Strain rate and temperature
Lecture 11 - Stress-strain rate relationship, strain rate sensitivity, superplasticity, effect of strain rate sensitivity and material
Lecture 12 - Inhomogeneity on uniform deformation, combined strain and strain rate effects
Lecture 13 - Temperature dependence of flow stress and temperature rise during deformation
[6]. Ideal work (or uniform energy)
Lecture 14 - Concept of ideal work, applications to extrusion
Lecture 15 – Analysis of wire rod drawing process and role of friction
Lecture 16 - Redundant work and mechanical efficiency, maximum drawing reduction
[7]. Slab analysis (or force balance)
Lecture 17 – Analysis of plane strain sheet drawing
Lecture 18 - Slab versus ideal work method, wire or rod drawing
Lecture 19 - Direct compression in plane strain, axisymmetric compression and flat rolling.
[8]. Formability
Lecture 20 - Role of microstructure and stress state on formability
Lecture 21 - Bulk formability and forming limits
Lecture 22 – Characteristics of ductile fracture.
[9]. Bending
Lecture 23 - Analysis of elastoplastic bending process
Lecture 24 - Springback analysis in sheet bending,
Lecture 25 - Bending with superimposed tension and sheet bendability.
[10]. Plastic anisotropy
Lecture 26 - Crystallographic basis of anisotropy of sheet materials
Lecture 27 - Measurement of anisotropy
Lecture 28 - Hill's theory of anisotropy
[11]. Cupping, redrawing and ironing
Lecture 29 - Analysis of cup drawing process,
Lecture 30 - Effect of work hardening on cup drawability, deformation efficiency, Lecture 31 - Effect of tool geometry on drawability, earing, redrawing and ironing of cups.
[12]. Sheet forming limits
Lecture 32 - Localized necking in biaxial stretching and forming limit diagrams (FLDs)
Lecture 33 - Experimental determination of FLDs
Lectur

Ankur Chauhan

Pre-requistes : None

References : [1]. Metal Forming by W. F. Hosford and R. M. Cadell, 4th Edn.
[2]. Fundamentals of Metal Forming by R. H. Wagoner and J-L. Chenot
[3]. Mechanics of sheet metal forming by Duncan, Sowerby and Hu, 2nd Edn.

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.

Pre-requistes : None

References : None

ME 228 (AUG) 3 : 0

Materials and Structure Property Correlations

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

Pre-requistes : None

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

ME 240 (AUG) 3 : 0

Dynamics and Control of Mechanical Systems

Representation of translation and rotation of rigid bodies, degrees of freedom and generalized coordinates, motion of a rigid body and multi-body systems,Lagrangian and equations of motion, small vibrations, computer generation and solution of equations of motion, review of feedback control, PID control, root locus, Bode diagrams, state space method, control system design and computer simulation.

Pre-requistes : None

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

ME 242 (AUG) 3 : 0

Solid Mechanics

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

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.

Pre-requistes : None

References :

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

ME 251 (JAN) 3 : 0

Biomechanics

Bone and cartilage, joint contact analysis, structure and composition of biological tissues. Continuum mechanics, constitutive equations,
nonlinear elasticity, rubber elasticity, arterial mechanics.
Introduction to cell mechanics.

Namrata Gundiah

Pre-requistes : None

References :

Humphrey, J.D., Cardiovascular Solid Mechanics,Springer-Verlag,

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.

Pre-requistes : None

References : None

ME 257 (JAN) 3 : 0

Finite Element Methods

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

Ramsharan Rangarajan

Pre-requistes : None

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

ME 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.

Pre-requistes : None

References : None

ME 271 (AUG) 3 : 0

Thermodynamics

Concepts of thermodynamics, zeroth law, first law, properties of pure substances and mixtures, first order phase transitions, thermophysical properties, energy storage; second law; energy analysis of process and cycle;calculation of entropy and entropy diagrams; availability analysis, chemical equilibrium, non-equillibrium thermodynamics, multi-phase-multi component systems, transport properties; third law

Pre-requistes : None

References : None

ME 272 (JAN) 3 : 0

Thermal Management of Electronics

Pradip Dutta , Amrit Ambirajan

Pre-requistes : None

References : None

ME 273 (JAN) 3 : 0

Solid and Fluid Phenomena at Small Scales

Intermolecular forces, surfaces,defects.Size-dependent strength, micro - mechanics of interfaces and thin films. Solvation forces, double layer forces,effect of physico-chemical forces on fluid flow at micron-scales. Slip boundary condition,friction and nano tribology. Nanoindentation, atomic force microscopy, micro-PIV and other characterizing techniques. MEMS, micro fluidics, microscopic heat pipes and other applications.

Raghuraman N Govardhan , Bobji M S

Pre-requistes : None

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

ME 274 (JAN) 3 : 0

Convective Heat Transfer

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

Pramod Kumar

Pre-requistes : None

References : None

ME 282 (JAN) 3 : 0

Computational Heat Transfer and Fluid Flow

Mathematical description of fluid flow and heat transfer, conservation equations for mass, momentum, energy and chemical species, classification of partial differential equations, coordinate systems. Discretization techniques using finite difference methods: Taylor series and control volume formulations. Irregular geometries and body-fitted coordinate system. Applications to practical problems.

Ratnesh K Shukla

Pre-requistes : None

References : None

ME 283 (JAN) 3 : 0

Two Phase Flows and Boiling Heat Transfer

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

Susmita Dash

Pre-requistes : None

References : None

ME 285 (AUG) 3 : 0

Turbomachine Theory

Introduction to turbo-machines, mixing losses, review of vorticity, profile changes in contracting and expanding ducts. Brief review of diffusers,rotating co-ordinate system, total enthalpy, rothalpy, Euler turbine equation,velocity triangles. Specific speed and Cordier diagram, cascade aerodynamics. Elemental compressor stage, reaction work and flow coefficients. Equations of motion in axisymmetric flow, simple and extended radial equilibrium. Elemental axial turbine stage, radial and mixed flow machines, work done by Coriolis forces and by aerofoil action, the centrifugal compressor, vaned and vaneless diffusers.

Pre-requistes : None

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

ME 287 (JAN) 3 : 0

Refrigeration Engineering

Methods of refrigeration, vapour compression refrigeration-standard and actual vapour compression cycles, multipressure systems, compressors, condensers, expansion devices, evaporators, refrigerants and refrigeration controls, component matching and system integration, vapour absorption refrigeration thermodynamics, single stage, dual stage and dual effect systems. Selection of working fluids, design of generators and absorbers, non- conventional refrigeration systems, vapour jet refrigeration.

Narasimham G S V L

Pre-requistes : None

References : Stoecker, W.F., and Jones, J.W., Refrigeration and Air conditioning, Second Edn, Tata McGraw Hill, 1982.,Therlkeld, J.L., Therm al Environm ent al Engineering, Prentice Hall, Inc., Englewood Cliffs, New Jersey, 1970.,ASHRAE Handbooks (SI Editions): Fundamentals (2009),Refrigeration (2010).

ME 288 (JAN) 3 : 0

Air Conditioning Engineering

Methods of refrigeration, vapour compression refrigeration-standard and actual vapour compression cycles, multipressure systems, compressors, condensers, expansion devices, evaporators, refrigerants and refrigeration controls,component matching and system integration, vapour absorption refrigeration thermodynamics, single stage, dual stage and dual effect systems. Selection of working fluids, design of generators and absorbers, non- conventional refrigeration systems, vapour jet refrigeration. Properties of air-water mixtures, psychometric chart,air conditioning processes, enthalpy potential, cooling and dehumidifying coils, cooling towers, heat transfer in buildings, comfort air conditioning, cooling load calculations, air conditioning system, design of air delivery systems, clean rooms and laminar flow equipment, air conditioning controls, noise and vibration control in air-conditioned rooms.

Narasimham G S V L

Pre-requistes : None

References : Stoecker, W.F., and Jones, J.W., Refrigeration and Air conditioning, Second Edn, Tata McGraw Hill, 1982.,Therlkeld, J.L., Therm al Environm ent al Engineering, Prentice Hall, Inc., Englewood Cliffs, New Jersey, 1970.,ASHRAE Handbooks (SI Editions): Fundamentals (2009),Refrigeration (2010). Jones, W.P., Air Conditioning Engineering, Fifth Edn,Butterworth Heinemann,Oxford, 2001.

ME 289 (AUG) 3 : 0

Principles of Solar Thermal Engineering

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

Pre-requistes : None

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

ME 293 (JAN) 3 : 0

Fracture Mechanics

Narasimhan R

Pre-requistes : None

References : None

ME 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.

Jishnu Keshavan

Pre-requistes : None

References : None

ME 299 (JAN) 0 : 27

Dissertation Project

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

Ratnesh K Shukla , Jishnu Keshavan

Pre-requistes : None

References : None

ME 303 (JAN) 3 : 0

Partial Differential Equations with Applications

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

Chandrashekhar S Jog , Venkata R Sonti

Pre-requistes : None

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

ME 254 (JAN) 3 : 0

Compliant Mechanisms

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

Ananthasuresh G K

Pre-requistes : None

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

ME 259 (AUG) 3 : 0

Nonlinear Finite Element Methods

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

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 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.

Pre-requistes : None

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

ME 280 (AUG) 3 : 0

Fundamentals of nanoscale conduction heat transport

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

Pre-requistes : None

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

ME 304 (JAN) 3 : 0

Applied Mathematics for Mechanics

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

Koushik Viswanathan

Pre-requistes :
Basic course in engineering mathematics (ME261 or equivalent) and knowledge of solid & fluid mechanics at the undergraduate level.
References : 1.Introduction to Partial Differential Equations with Applications by Zachmanoglou and Thoe; 2.An Introduction to Partial Differential Equations by Renardy and Rogers; Applied Partial Differential Equations by R. Haberman;Elements of Partial Differential Equations by Ian N. Sneddon; 3.Introduction to Partial Differential Equations by L.C. Evans Ablowitz, M. J., Fokas, A. S. (2003). 4.Complex

ME 292 (JAN) 3 : 0

Contact and Impact Mechanics

Brief overview of elasticity and linear-elastic fracture mechanics; point and line loading of an elastic half space; frictionless contact mechanics of rigid and deformable bodies; force interactions between atoms and molecules (bonded and non-bonded short and long-range interactions); forces between particles and surfaces; adhesive contact mechanics; friction; application of contact mechanics in instrumented nanoindentation and atomic force microscopy; introduction to impact mechanics of rigid and deformable bodies; latest research on contact and impact mechanics.

Debashish Das

Pre-requistes :
ME-242/ ME-293: Solid/Fracture Mechanics or an equivalent course is desirable or the instructor's permission.
References : 1. K. L. Johnson, Contact Mechanics, Cambridge University Press

2. J. N. Israelachvili, Intermolecular and surface forces, Academic Press, 3rd Edition

ME 232 (JAN) 3 : 0

Applied Dynamics II

This is the second of 2 Applied Dynamics courses. Course I emphasizes tools needed for analysis of rigid body motion. This course will consider the dynamics or particular systems. The exact list of topics and their emphasis will depend on student interest. Likely topics include: Robot arms (forwards and inverse kinematics and dynamics), simple models of walking (balance and energetics), airplane dynamics in 2D (lift, drag, L/D, static margin, phugoid motions, stability), sailboat statics and dynamics (lift, drag, sailing upwind, Lanchester Course Theorem), the falling cat (rotation with zero angular momentum), car dynamics (tire models, over- and under-steer, stability), bicycle dynamics (control and dynamics), drones (control and dynamics) etc.

Jishnu Keshavan

Pre-requistes : Applied Dynamics I (or equivalent). Familiarity with MATLAB will be strongly preferred. Representative Matlab commands that you should be

References : 1. Instructor's lecture notes.

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.

Pre-requistes : Undergraduate Engineering Mathematics courses that include: vectors, linear algebra, differential equations, facility with computers (This course will use Matlab, but facility with any programming language suffices as preparation).

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

ME 202 (JAN) 3 : 0

Microhydrodynamics

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

Shubhadeep Mandal

Pre-requistes :
Basic knowledge of fluid mechanics and differential equations are essential.

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

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.

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

Pre-requistes : None

References : None

MN 203 (JAN) 3 : 0

Design for Additive Manufacturing

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

Gurumoorthy B , Ananthasuresh G K

Pre-requistes : None

References : None

MN 204 (JAN) 3 : 0

Human Machine Interaction for Manufacturing

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

Pradipta Biswas

Pre-requistes : None

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

MN 205 (AUG) 1 : 2

Makers' Project

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

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.

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 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.

Pre-requistes : None

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

PD 205 (JAN) 2 : 1

Materials, Manufacturing and Design

Material usage and sustainability issues, concept or closed and open loop.Engineering materials, metals and their properties, uses, processing methods,design data and applications, material selection criteria, manufacturing and processing of materials. Plastics and composites, types, classification,properties, processing techniques and limitations, basics of reliability,failure and failure analysis.

Anindya Deb

Pre-requistes : None

References : Dieter, G.E., Engineering Design – A Materials and processing approach, McGraw Hill, 1991.,Ashby, M.F., Materials selection in Mechanical Design, Pergamon press, 1992.,Patton, W.J., Plastics Technology, Theory, Design and Manufacture, Lenton Publishing Co.

PD 207 (AUG) 1 : 2

Product Visualization, Communication and Presentation

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

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

Pre-requistes : None

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

PD 211 (JAN) 2 : 1

Product Design

Semiotic studies – product semantics, syntactics, and pragmatics. Study of expressions, metaphors, feelings, themes. Study of product evolution, problem identification, design methods, design process, design brief, concept generation, concept selection, design and development, product detailing,prototyping, design evaluation.

Vishal Singh

Pre-requistes : None

References : Papanek, V., Design for the Real World, Thames & Hudson, London.,Ulrich, K.T.,and Eppinger, S.D., Product Design and Development,Tata McGraw Hill, India.

PD 212 (JAN) 2 : 1

Computer Aided Design

Industry best practices, business and competitive strategy,product strategy and product planning, business planning,platform-based product development,market selection, ideation to prototyping, strategic fit, industry project based experiential learning with prototype development and business planning deliverables CAD – modeling of curves, surfaces and solids manipulation of CAD models,features based modeling, parametric/ variational modeling, product data exchange standards. Introduction to CAID, surfaces. Interfacing for production and tool design, photo rendering and scanning, 3D animation and morphing,studio exercise in virtual products and systems.

Gurumoorthy B

Pre-requistes : None

References : Zeid, I.,,CAD/CAM,,McGraw Hill

PD 215 (JAN) 2 : 1

Mechatronics

Introduction to mechatronics – overview of mechatronic products and their functioning. Survey of mechatronical components, selection and assembly for precision-engineering applications. Study of electromechanical actuators and transducers. Load analysis and actuator selection for typical cases such as computer peripherals. Study of electronic controllers and drives for mechanical products. Interfacing of mechanical and electronic systems. Design assignments and practical case studies.

Manish Arora , Abhra Roy Chowdhury

Pre-requistes : None

References : Bolton, W Mechatronics, Longman, 2015,Kuo, B.C., D.C.Motors and Control systems, SRL Publishing Co., 1979.,Kuo, B.C., Step Motors and Control Systems, SRL Publishing Co., 1979.

PD 217 (AUG) 2 : 1

CAE in Product Design

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

Pre-requistes : None

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

PD 218 (JAN) 1 : 2

New Product Development: Strategy and Practice

Industry best practices, business and competitive strategy, product strategy and product planning, business planning, platform-based product development,market selection, ideation to prototyping, strategic fit, industry project based experiential learning with prototype development and business planning deliverables

Gurumoorthy B

Pre-requistes : None

References : None

PD 221 (JAN) 2 : 1

Methodology for Design Research

Introduction to design research, a methodology for design research and its components, types of design research, selecting criteria and its research methods, understanding factors influencing design and its research methods,developing design support and its research methods, evaluating design support and its research methods,associated exercises and tests.

Amaresh Chakrabarti

Pre-requistes : None

References : Blessing, L.T.M., Chakrabarti, A., and Wallace, K.M., An Overview of Design Studies in Relation to a Design Research Methodology. ,Frankengerger and Badke-Schaub (Eds), Designers: The Key to Successful Product Development, Springer Verlag, 1998.,Current Literature including papers from Proceedings of the International Conference in Engineering Design, Prague, 1995.

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.

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.

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.

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.

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 235 (JAN) 2 : 1

Mechanism Design

CAD – modeling of curves, surfaces and solids manipulation of CAD models,features based modeling, parametric/ variational modeling, product data exchange standards. Introduction to CAID, surfaces. Interfacing for production and tool design, photo rendering and scanning, 3D animation and morphing,studio exercise in virtual products and systems. Introduction to mechatronics – overview of mechatronic products and their functioning. Survey of mechatronical components, selection and assembly for precision-engineering applications. Study of electromechanical actuators and transducers. Load analysis and actuator selection for typical cases such as computer peripherals. Study of electronic controllers and drives for mechanical products. Interfacing of mechanical and electronic systems. Design assignments and practical case studies.Classification of automotive systems, interfacing of marketing, design andmanufacturing, converting customer's needs into technical targets,vehicle design process.

Dibakar Sen

Pre-requistes : None

References : Zeid, I.,,CAD/CAM,,McGraw Hill Bolton, W Mechatronics, Longman, 2015,Kuo, B.C., D.C.Motors and Control systems, SRL Publishing Co., 1979.,Kuo, B.C., Step Motors and Control Systems, SRL Publishing Co., 1979. 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.,

PD 236 (JAN) 2 : 1

Embodiment Design

Introduction to design research, a methodology for design research and its components, types of design research, selecting criteria and its research methods, understanding factors influencing design and its research methods,developing design support and its research methods, evaluating design support and its research methods, associated exercises and tests. Embodiment methodology, basic components and interfaces, design for performance including strength, usability, maintenance and reliability, Designfor manufacturing, assembly, packaging, distribution, services, cost and environmental impact. Dimensioning, tolerance and standards.

Amaresh Chakrabarti , Abhijit Biswas

Pre-requistes : None

References : Blessing, L.T.M., Chakrabarti, A., and Wallace, K.M., An Overview of Design Studies in Relation to a Design Research Methodology. ,Frankengerger and Badke-Schaub (Eds), Designers: The Key to Successful Product Development, Springer Verlag, 1998.,Current Literature including papers from Proceedings of the International Conference in Engineering Design, Prague, 1995 Pahl, G

PD 239 (AUG) 0 : 3

Design and Society

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

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 (JAN) 2 : 1

Design of Automotive Systems

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

Anindya Deb

Pre-requistes : None

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

PD 230 (JAN) 3 : 0

Haptic Systems Design

Abhijit Biswas

Pre-requistes : None

References : None

PD 204 (AUG) 2 : 1

Basics of Electronics for Product Design and Manufacturing

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

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.

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

Pre-requistes :
Familiarity with following is desired but not essential
• Linear Algebra; Ordinary Differential Equations; Probability

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 : -

MN 208 (JAN) 2 : 1

ANALYSIS AND DESIGN OF COMPOSITE STRUCTURES

Definition and classification of composites based on the matrix (polymer matrix composites (PMCs), metal matrix composites (MMCs), and ceramic matrix composites (CMCs)) and reinforcements (continuous, woven, discontinuous). Introduction to hybrid composites, bio-composites, and green composites. Manufacturing processes of PMCs: open and closed mould processing, hand layup techniques, vacuum bag moulding, autoclave moulding, filament winding, pultrusion, thermoforming, injection moulding, and resin transfer moulding. Review of mechanics of materials, stress and strain transformation, constitutive relations for anisotropic materials, classical lamination plate theory, failure theories, and design of composite structures.

Shivakumar N D

Pre-requistes : None

References : 1. Daniel, I. M., Ishai, O., Daniel, I. M., & Daniel, I. (2006).Engineering mechanics of composite materials(Vol. 1994). New York: Oxford university press.
2. Kaw, A. K. (2005).Mechanics of composite materials. CRC press.

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 316 (JAN) 3 : 0

Group Theory and Applications in Physics

"Symmetries and group theory. Finite and continuous groups with examples.Group operations and representations. Homomorphism, isomorphism and automorphism. Reducibility, equivalence, Schur's lemma. Permutation groups,Young diagrams. Lie groups and Lie algebras. SU(2), SU(3) and applications.Roots and weights. Dynkin diagrams. Classification of compact simple Lie algebras. Exceptional groups "

Ananthanarayan B

Pre-requistes : None

References : "Georgi H., Lie Algebras in Particle Physics (Second edition), Perseus Books,1999.Mukhi S. and Mukunda N., Introduction to Topology, Differential Geometry and Group Theory for Physicists, Wiley Eastern, 1990.Hamermesh M.,Group Theory and its Applications to Physical Problems,Addison-Wesley, 1962. "

HE 392 (JAN) 3 : 0

Standard Model of Particle Physics

"Fermions coupled to gauge fields. Tree-level QED processes. Weak interactions before gauge theory. V-A theory, massive vector bosons. Spontaneous symmetry breaking, Goldstone bosons, Higgs mechanism. Charged and neutral currents,gauge symmetries and SU(2)xU(1) Lagrangian. Flavour mixing, GIM mechanism. CP violation, K/B systems. Neutrinos. Electroweak precision measurements.

Chethan Krishnan

Pre-requistes : None

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

HE 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.

Pre-requistes : None

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

HE 398 (JAN) 3 : 0

General Relativity

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

Biplob Bhattacherjee

Pre-requistes : None

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

HE 396 (JAN) 3 : 0

Quantum Field Theory II

Abelian gauge theories. QED processes and symmetries. Gauge invariance, covariant derivatives, massless photons, Ward identity. Loop diagrams and 1- loop renormalization. Lamb shift and anomalous magnetic moments. Nonabelian gauge theories. Faddeev-Popov ghosts. BRST quantization. QCD beta function, asymptotic freedom. Spinor helicity formalism for gauge theories. Composite operators, operator product expansion. Anomalies. Lattice gauge theory, strong coupling expansion. Confinement and chiral symmetry breaking.

Sachindeo Vaidya

Pre-requistes : None

References : Schwartz M.D., Quantum field theory and the standard model, Cambridge University Press, 2014.~Srednicki M., Quantum Field Theory, Cambridge University Press, 2007.~Weinberg S., The Quantum Theory of Fields, Vol. I: Foundations, Vol. II: Modern Applications, Cambridge University Press, 1996. ~Peskin M.E. and Schroeder D.V., An Introduction to Quantum Field Theory, Addison

HE 394 (JAN) 3 : 0

Cosmology for Theorists

FLRW metric, redshift and cosmography, measuring distances, concordance LCDM model - dark matter/ energy, thermal history, nucleosynthesis, inflation, perturbation theory, evolution of perturbations and structure, CMB anisotropies, tension(s) between early and late universe.

Gaurav Narain

Pre-requistes : Exposure to general relativity at the level of Einstein's equations and Schwarzschild solution, and exposure to QFT at the level of scalar field

References : Mukhanov - "Physical Foundations of Cosmology", Weinberg - "Cosmology"

HE 379 (AUG) 3 : 0

Physics Beyond Standard Model

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

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

References : Csaki's lecture notes, orignial papers.

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.

Pre-requistes : None

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

IN 214 (JAN) 3 : 0

Semiconductor Devices and Circuits

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

Sanjiv Sambandan

Pre-requistes : None

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

IN 221 (AUG) 3 : 0

Sensors and Transducers

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

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 224 (JAN) 3 : 0

Nanoscience and Device fabrication

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 Nanoscience: Introduction, classification, Summary of electronic properties of atoms and solids, Effects of the nanometer length scale, General methodologies for nanomaterial characterization, semiconductor physics - semiconductor nanostructures, Quantum confinement in semiconductor nanostructures,Modulation doping, Interband/Intraband absorption in semiconductor nanostructures, Phonon bottleneck, thermodynamics and kinetics of phase transformations, Applications of semiconductor nanostructures Device fabrication: Growth techniques and properties, thin film phenomena, PVD and CVD techniques, MBE-growth of sel

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 227 (JAN) 3 : 0

Control Systems Design

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

Jayanth G R

Pre-requistes : None

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

IN 232 (AUG) 3 : 0

Concepts in solid state physics

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

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 234 (JAN) 3 : 0

Biomedical Optics and Spectroscopy

Mathematical Preliminaries: Signal Processing, Probability and Linear Algebra. A brief introduction to medical imaging, basic principles of imaging modalities such as x-ray, CT, SPECT, PET, MRI,Ultrasound. Basics of Spectroscopy: Infrared Spectroscopy, Raman Spectroscopy, Fluorescence Spectroscopy and Optoacoustic spectroscopy. Introduction to biomedical optics, single-scatterer theories, Monte Carlo modelling of photon transport,convolution for broad-beam responses, radiative transfer equation and diffusion theory, hybrid model of Monte Carlo and diffusion theory, sensing of optical properties and spectroscopy, optical coherence tomography basics, diffuse optical tomography, optoacoustic tomography, and ultrasound modulated optical tomography. Spectroscopy in the context of imaging.

Jaya Prakash

Pre-requistes : None

References : Lihong V. Wang and Hsin-i Wu, Biomedical Optics: Principles and Imaging, Wiley, (2007). ISBN: 978-0-471-74304-0.~Valery Tuchin, Tissue Optics: Light Scattering Methods and Instruments for Medical Diagnosis, SPIE Press (2007). ~Jerry L. Prince and Jonathan M. Links, Medical Imaging Signals and Systems,Prentice Hall, (2005).

IN 244 (JAN) 2 : 1

Optical Metrology

(1) Active Stereo-Vision Techniques: Introduction to Light-based Dimensional Metrology, Pinhole Camera Model, Camera Calibration, Laser Triangulation, Structured Illumination Techniques, Fringe Analysis, Phase Unwrapping, System Calibration Techniques.
(2) Interferometric Techniques: Introduction to Interferometry based Instrumentation, Michelson, Holographic, and Common-Path Interferometers and their applications in Metrology.
(3) Optical Microscopy: Basics of Microscopy, Digital Microscopy for 2-D and 3-D measurements, Optical Sectioning, Super-resolution, Surface Profiling and Quantitative Phase Imaging.

This course also provides hands-on experience for important representative experimental techniques such as Michelson Interferometry, 4-f System, Stereo Vision, Fringe Projection Profilometry, and Quantitative Imaging (Microscopy).

Sai Siva Gorthi

Pre-requistes : All assignments and exercises (experiential part) would warrant implementing the codes in MATLAB / Python to analyze the images. Thus, familiarity with MATLAB / OpenCV is helpful, if not mandatory.

References : References
1) "Optical Metrology" by Kjell J.Gasvik
2) "Introduction to Fourier Optics" by Joseph W.Goodman

IN 267 (AUG) 3 : 0

Fluorescence Microscopy and Imaging

Light Sources, Monochromators, Optical Filters, Photomultiplier tubes, polarizers, Beer-Lambart Law, Paraxial ray Optics and System Designing, Wave Optics, electromagnetic theory, fluorescence microscopy systems, molecular physics, photo-physics and Stern-Volmer equation, Jablonski diagram, emission spectra, fluorescence lifetime and quantum yield, time-domain lifetime measurements, fluorescence correlation spectroscopy, total internal reflection fluorescence microscopy, electric field effects, point spread function, single- and multi-photon fluorescence microscopy, advanced super resolution microscopy, aperture engineering techniques, 3D image reconstruction, Markov random field, maximum likelihood algorithm, Bayes theorem.

Pre-requistes : None

References : None

IN 270 (AUG) 3 : 0

Digital Signal Processing

Signals and Systems Review, Time scaling and shifting, Amplitude scaling and shifting, LTI Systems, Properties of Signals and Systems, CTFS, CTFT, Nyquist Sampling Theorem, Reconstruction of Bandlimited Signals, DTFS, DTFT, Discrete Fourier Transform, Properties of Fourier Transform, existence of Fourier Transform. Laplace transform and its properties, z-transform and its properties. Signal Flow graphs, FIR and IIR filter realization. Impulse invariance method, and Bilinear transformation. Low-Pass Filtering, Filter design - Chebyschev Filter, Butterworth Filter and linear-phase filters. Windowing and Parks-McClellan Algorithm. Multi-resolution analysis, Filter Banks, Short-time Fourier Transform, Wavelets. 1D & 2D signals and its property, Sub-Nyquist Sampling, Reconstruction with uniform and non-uniform sampling (prior constraints): Pseudo-inverse, Truncated SVD, Minimum Norm Solution, Tikhonov Regularization, Iterative Methods, Majorization-Minimization, and Compressive Sampling.

Pre-requistes : Signals and Systems & consent from the instructor

References :
Textbooks:

IN 222 (JAN) 2 : 1

Sensors and Transducers Laboratory

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

Atanu Kumar Mohanty , Jayanth G R , Baladitya Suri

Pre-requistes : None

References : 1. W. Bolton, Mechatronics, Longman, 2015

IN 252 (JAN) 3 : 0

Optical materials and devices

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

Tapajyoti Das Gupta

Pre-requistes : None

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

IN 203 (AUG) 3 : 0

Micro to Quantum Supercapacitor Devices

Fundamentals of supercapacitor, Supercapacitor Fabrication, State-of-art supercapacitor design, Supercapacitor materials, Macro supercapacitor, Planar micro supercapacitor, Self-powered supercapacitor, Design of planar supercapacitor electrodes, Differences in macro-supercapacitor and planar supercapacitors, Mechanism of electrochemical interactions, Energy density and power density, Fundamentals of electromagnetic interaction in device design, Optically active devices and circuit design, Instrumentation of supercapacitor, Flexible electronics of supercapacitor, Ultra small planar devices, Device design parameters, Quantum Supercapacitors, Current technological advancements and future roadmap, Future Applications

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.)

Pre-requistes : None

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

IN 299A (JAN) 0 : 20

M Tech Project

Research project for fulfillment of M Tech degree requirements

Baladitya Suri

Pre-requistes : None

References : Project-specific references

Mathematics

Preface

MA 201 (JAN) 7 : 0

Project

Harish Seshadri

Pre-requistes : None

References : None

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.

Pre-requistes : None

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

MA 213 (JAN) 3 : 1

Algebra - II

Part A 1. Introduction to categories and functors, direct and inverse limits;2. Field of fractions of an integral domain, localization of rings; 3. i-adiccompletion of rings; 4. Tensor products, short exact sequences of modules; 5. Noetherian rings and modules, Hilbert Basis Theorem, Jordan-Holder Theorem; 6. Artinian rings, Artinian implies Noetherian, Krull-Schmidt Theorem. Part B 1. Splitting fields, normal and separable extensions; 2. Application to finite fields; 3. The Fundamental Theorem of Galois Theory; 4. The Primitive Element Theorem.

Radhika Ganapathy

Pre-requistes : None

References : None

MA 215 (JAN) 3 : 0

Introduction to Modular Forms

Mahesh Ramesh Kakde

Pre-requistes : None

References : None

MA 219 (AUG) 3 : 1

Linear Algebra

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

Pre-requistes : None

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

MA 220 (AUG) 3 : 0

Representation theory of Finite groups

Representation of finite groups, irreducible representations, complete reducibility, Schur's lemma, characters, orthogonality, class functions, regular representations and induced representation, the group algebra. Linear groups: Representation of the group SU2 Books Aritin, M., Algebra, Prentice Hall of India, 1994. Fulton W., and Harris, J., Representation Theory,Spinger-Verlag, 1991. Serre, J.P., Linear Representations of Finite Groups,Springer-Verlag, 1977.

Pre-requistes : None

References : Etingof Pavel, Golberg Oleg, Hensel Sebastian, Liu Tiankai, Schwendner Alex,Vaintrob Dmitry, Yudovina Elena,, Introduction to representation theory. With historical interludes by Slava Gerovitch, Student Mathematical Library 59. American Mathematical Society. 2011.~J. P. Serre. Graduate Texts in Mathematics. Vol. 42. Springer-Verlag. New York-Heidelberg, 1977.

MA 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.

Pre-requistes : None

References :
Rudin W. Principles of Mathematical Analysis. 3rd edition. McGraw-Hill International Edition.~Tao T. Analysis I. 3rd edition. TRIM series.

MA 223 (AUG) 3 : 0

Functional Analysis

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

Pre-requistes : None

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

MA 224 (JAN) 3 : 1

Complex Analysis

Complex numbers, complex-analytic functions, and the Cauchy-Riemann condition. Cauchy’s integral integral formula, power series. Liouville’s theorem and applications. The maximum-modulus principle. Morera’s theorem, Schwartz reflection principle. Isolated singularities and the residue theorem. Contour integration. Möbius transformations, conformal mappings. Normal families and Montel's theorem. The Riemann Mapping Theorem. The Schwarz Lemma: proof, applications, automorphisms of the unit disc. Basics of analytic continuation (time permitting).

Bharathwaj Palvannan

Pre-requistes : None

References : None

MA 231 (AUG) 3 : 1

Topology

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

Pre-requistes : None

References :
Armstrong, M. A., Basic Topology, Springer (India), 2004., Functional Anaysis (2nd Ed.), McGraw-Hill, 2006.~Munkres, K. R., Topology,Pearson

MA 232 (AUG) 3 : 0

Introduction to Algebraic Topology

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

Pre-requistes : None

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

MA 241 (JAN) 3 : 1

Ordinary Differential Equations

Basics concepts:Introduction and examples through physical models, First and second order equations, general and particular solutions, linear and nonlinear systems, linear independence, solution techniques. Existence and Uniqueness Theorems :Peano's and Picard's theorems, Grownwall's inequality, Dependence on initial conditions and associated flows. Linear system:The fundamental matrix, stability of equilibrium points, Phase- plane analysis, Sturm-Liouvile theory . Nonlinear system and their stability:Lyapunov's method, Non-linear Perturbation of linear systems, Periodic solutions and Poincare- Bendixson theorem

Arka Mallick

Pre-requistes : None

References : 221,Coddington, E. A. and Levinson, N., Theory of Ordinary Differential Equations ,Tata McGraw-Hill, 1972,Perko, L., Differential Equations and Dynamical Systems ,Springer-Verlag, 1991.

MA 242 (AUG) 3 : 0

Partial Differential Equations

Pre-requistes : None

References : Garabedian, P. R., Partial Differential Equations, John Wiley and Sons, 1964. ~Fritz John, Partial Differential Equations, Springe

MA 261 (AUG) 3 : 0

Probability Models

Sample spaces, events, probability, discrete and continuous random variables,Conditioning and independence, Bayes formula, moments and moment generating function, characteristic function, laws of large numbers, central limit theorem, Markov chains, Poisson processes.

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 278 (JAN) 3 : 0

Introduction to Dynamical Systems Theory

Linear Stability analysis, attracters, limit cycles, Poincare-Bendixson theorem, relaxation oscillations.Elements of Bifurcation theory, saddle-node,transcritical, pitchfork and Hopf bifurcations. Integrability, Hamiltonian systems, Lotka-Volterra equations. Lyapunov functions and dirct methods for stability, dissipative systems, Lorenz systems, chaos and its measures,Lyapunov exponents, strange attractors, simple maps, period-doubling bifurcations, Feigenbaum constants, fractals.

Arvind Ayyer

Pre-requistes : None

References : None

MA 310 (JAN) 3 : 0

Algebraic Geometry I

Refresher on Commutative Algebra: localization, local rings, integral closure,Krull dimension. Zariski topology, Hochster's characterization of Zariski topology, spectral spaces. Zariski spectrum as a frame Refresher on categories : Categories, functors, Yoneda Lemma, equivalence of categories, adjoints.Grothendieck sites : Zariski, '{e} tale and Nisnevich sites. Presheaves and Sheaves Locally ringed spaces and schemes Separated schemes, proper schemes,irreducible schemes, reduced schemes, integral schemes, noetherian schemes.Morphisms : separated, proper, finite morphisms, finite type morphisms, affine morphisms Sheaves of algebras : affine morphisms as sheaves of algebras Sheaves of modules over a scheme, Quasi-coherent and coherent sheaves Divisors and Line Bundles, Weil divisors, Cartier divisors, Line bundles on Projective spaces, Serre sheaves. Projective morphisms, ample and very ample line bundles Formal schemes

Amalendu Krishna

Pre-requistes : None

References : None

MA 312 (AUG) 3 : 0

Commutative Algebra

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

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.

Pre-requistes : None

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

MA 315 (AUG) 3 : 0

Lie Algebra and Their Representation

Finite dimensional Lie algebras, Ideals, Homomorphisms, Solvable and Nilpotent Lie algebras, Semisimple Lie algebras, Jordan decomposition, Kiling form, root space decomposition, root systems, classification of complex semisimple Lie algebras Representations Complete reducibility, weight spaces, Weyl character formula, Kostant, steinberg and Freudenthal formulas

Pre-requistes : None

References : J E Humphreys Introduction to Lie algebras and Representation theory Springer-Verlag, 1972~J P Serre Complex Semisimple Lie Algebras, Springer, 2001~Fulton.W., and Harris J. Representation theory, Springer- Verlag. 1991

MA 317 (AUG) 3 : 0

Introduction to Analytic Number Theory

Pre-requistes : None

References : None

MA 318 (JAN) 3 : 0

Combinatorics

Arvind Ayyer

Pre-requistes : None

References : None

MA 321 (AUG) 3 : 0

Analysis III

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

Pre-requistes : None

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

MA 325 (AUG) 3 : 0

Operator Theory - II

Pre-requistes : None

References : None

MA 326 (JAN) 3 : 0

Fourier Analysis

Introduction to Fourier Series; Plancherel theorem, basis approximation theorems, Dini’s Condition etc. Introduction to Fourier transform; Plancherel theorem, Wiener-Tauberian theorems, Interpolation of operators, Maximal functions, Lebesgue differentiation theorem, Poisson representation of harmonic functions, introduction to singular integral operators.

Narayanan E K

Pre-requistes : None

References : None

MA 329 (AUG) 3 : 0

Topics in Several Complex Variables

Pre-requistes : None

References : None

MA 350 (JAN) 3 : 0

Analytic Number Theory

Soumya Das

Pre-requistes : None

References : None

MA 353 (JAN) 3 : 0

Elliptic Curves

Elliptic curves are smooth projective curves of genus 1 with a marked point.cOver a field of characteristic zero they are given by an equation of the form y^2=x^3+ax+b. They are at the boundary of our (conjectural) understanding of rational points on varieties and are subject of many famous conjectures as well as celebrated results. They play an important role in number theory. The course will begin with an introduction to algebraic curves. We will then study elliptic curves over complex number, over finite fields, over local fields of characteristic zero and finally over number fields. Our goal will be to prove the Mordell-Weil theorem.

Shaunak Vilas Deo

Pre-requistes : None

References : Joseph Silverman, The arithmetic of elliptic curves, Springer GTM 106, 2009~Joseph Silverman and John Tate, Rational points on elliptic curves, Springer UTM, 1992~J.W.S. Cassels, Lectures on elliptic curves, Cambridge University Press, 2012

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.

Pre-requistes : None

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

MA 368 (JAN) 3 : 0

Topics in Probability and Stochastic Processes

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)

Manjunath Krishnapur

Pre-requistes : None

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

MA 399 (AUG) 2 : 0

Seminar in Topics in Mathematics

Pre-requistes : None

References : None

MA 200 (AUG) 3 : 1

Multivariable Calculus

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

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 222 (JAN) 3 : 1

Analysis II

Sigma-algebras, outer measures and measures. Construction of Lebesgue measure. Measurable functions. Lebesgue integration and integration with abstract measures. Monotone convergence theorem, Fatou's lemma and the dominated convergence theorem. Comparison of Riemann integration and Lebesgue integration. Product sigma-algebras, product measures, Fubini's theorem. Signed measures and the Radon-Nikodym theorem. L^p spaces, characterization of continuous linear functionals on L^p spaces. Complex measures, the Riesz representation theorem.

Gautam Bharali

Pre-requistes : None

References : Stein E. M. and Shakarchi R. Real analysis: measure theory. integration and Hilbert spaces. Princeton university press (2005).~Folland G.B. Real Analysis:Modern Techniques and their Applications (2nd Ed.) .Wiley. ~Royden H. L. Real Analysis .Macmillan. 1988.~Hewitt E. and Stromberg. K. Real and Abstract Analysis. Springer. 1969.

MA 308 (JAN) 3 : 0

Basic Algebraic Geometry

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

Abhishek Banerjee

Pre-requistes : None

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

MA 321 (AUG) 3 : 0

Analysis III

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

Pre-requistes : None

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

MA 374 (JAN) 3 : 0

Introduction to the Calculus of Variations

Our goal is to cover the following topics:

Classical Methods: Euler-Lagrange equations, Lagrangian and Hamiltonian formulations, Hamilton-Jacobi equations, constrained problems and Lagrange multipliers, An illustration of the methods: Geodesic curves.

Direct Methods: Dirichlet integral and p-Dirichlet Integral: Existence of minimizers: Existence theorem for convex functional with lower order terms, examples and counterexamples, weak form of the Euler-Lagrange equations, Dirichlet Principle, weak continuity of determinants. Regularity questions.

Plateau's problem and minimal surfaces: Parametric Plateau's problem: Douglas-Courant-Tonelli method, Regularity, uniqueness and nonuniqueness, Nonparametric minimal surfaces, Isoperimetric inequality.

Swarnendu Sil

Pre-requistes : MA 221, MA 222, MA 223
MA 221, MA 222, MA 223

References :
1. Dacorogna, B., Introduction to the calculus of variations, third ed., Imperial College Press, London, 2015.

MA 235 (JAN) 3 : 0

Introduction to differentiable manifolds

A review of continuity and differentiability in more than one variable. The inverse, implicit, and constant rank theorems. Definitions and examples of manifolds, maps between manifolds, regular and critical values, partition of unity, Sard's theorem and applications. Tangent spaces and the tangent/cotangent bundles, definition of general vector bundles, vector fields and flows, Frobenius' theorem. Tensors, differential forms, Lie derivative and the exterior derivative, integration on manifolds, Stokes' theorem. Introduction to de Rham cohomology.

Subhojoy Gupta

Pre-requistes :
MA 221 (Analysis I), MA 219 (Linear Algebra), and MA 231 (Topology).

References : 1. Tu, Loren An Introduction to Manifolds, Universitext, Springer-Verlag 2011. 2. John Lee, Introduction to Smooth Manifolds, Graduate Texts in Mathematics 218, Springer-Verlag 2012. 3. Barden, Dennis and Thomas, Charles, An Introduction to Differential Manifolds, World Scientific 2003. 4. Spivak, Michael Comprehensive Introduction to Differential Geometry, Vol 1, Publish or Perish, 2005.

MA 375 (AUG) 3 : 0

Algebraic graph theory

Basic definitions in graph theory, line graphs, some matrices related to graphs and their spectral properties, the Perron-Frobenius theorem, Cauchy's interlacing theorem, strongly regular graphs, the Laplacian matrix, cuts and flows.

Pre-requistes :
Background in Linear algebra.

References : 1. Chris Godsil and Gordon Royle, Algebraic graph theory, Graduate Texts in Mathematics, 207. Springer-Verlag, New York, 2001, ISBN:0-387-95220-9.
2. R. B. Bapat, Graphs and matrices, New Delhi: Hindustan Book Agency, 2012, TRIM 58.

MA 388 (AUG) 3 : 0

Topics in Non-linear Functional Analysis

In this course, our main aim is to develop abstract variational techniques which can be employed to study the existence of solutions of various Semi-linear elliptic Partial Differential Equations. The main fundamental results, that will be covered in this course, are functional analytic in nature and can be used in many other situations. A basic outline of the course is as follows:
1. The Pohozaev identity and non-existence of solutions.
2. Calculus in normed linear space: Fréchet and Gâteaux differentiability, Notion of integral, Existence and uniqueness theorem for ODE in Banach space.
3. Dirichlet's principle, Basics of Sobolev spaces, Connection between critical points and solutions of PDE
4. Direct Methods in Calculus of Variations:Existence of extrema, Ekeland's Variational Principle, Constrained critical points (method of Lagrange Multiplier).
5. Deformation and the Palais-Smale condition, Saddle points and min-max methods: The mountain pass theorem and its application, The

Pre-requistes : MA 222, MA 223

References :
1. Ambrosetti, A., and Malchiodi, A. (2007). Nonlinear Analysis and Semilinear Elliptic Problems (Cambridge Studies in Advanced

MA 262 (JAN) 3 : 0

Introduction to Stochastic Processes

Discrete parameter Markov Chains: Chapman-Kolmogorov equations, Classification of states, Limit Theorems, Examples: Random Walks, Gambler's Ruin, Branching processes. Time reversible Markov chains. Simulations and MCMC; Poisson processes: Definitions, and properties: interarrival and waiting time distributions, superposition and thinning, Nonhomogeneous Poisson process, Compound Poisson process. Simulation; Continuous time Markov Chains: Definition, Birth-Death processes, Kolmogorov backward and forward equations, Limiting probabilities, Time reversibility. Queueing Theory, Simulation; Renewal Theory; Brownian Motion.

Srikanth Krishnan Iyer

Pre-requistes :
UM201 or equivalent.

References : Samuel Karlin and Howard M. Taylor: A first course in Stochastic Processes, 2nd edition, Academic Press, 1975.
Sheldon M. Ross: Stochastic Processes, 2nd edition, John Wiley and Sons, 2008.
Rabi N. Bhattacharya and Edward C. Waymire: Stochastic Processes and Applications, Siam, 2009.

MA 208 (JAN) 3 : 1

Proofs and Programs

This course introduces various aspects of Computer Proofs, both interactive and fully automated. We will consider proofs of mathematical results as well as of correctness of programs. We will primarily use the Lean Theorem Prover 4, which is a formal proof system as well as a programming language. The foundations on which the lean prover is based, Dependent Type Theory, allow a seamless integration of mathematical objects, theorems, proofs and algorithms.

Topics covered will be among the following.
* Interactively proving mathematical results in the lean theorem prover.
* Programming in lean - functional programming with dependent types.
* Mathematical proofs of correctness of programs.
* Foundations of Mathematics and Computation using Dependent Type Theory
* First-order logic
* Fully automated theorem proving: SAT Solvers, Resolution Theorem Proving etc.
* Use of Machine Learning in Automated and Interactive Theorem Proving.

Siddhartha Gadgil

Pre-requistes :
Familiarity with mathematical proofs and some basic mathematics such as linear algebra and group theory
References : 1. Jeremy Avigad, Leonardo de Moura, Soonho Kong and Sebastian Ullrich, Theorem Proving in Lean 4, available online at https://leanprover.github.io/theorem_proving_in_lean4/

MA 348 (JAN) 3 : 0

Topics in function theoretic operator Theory

Banach algebras – Gelfand theory, L-infinity functional calculus for bounded normal operators, Pick - Nevanlinna and Caratheodory Interpolation problems, Distinguished varieties in the bidisc.

Tirthankar Bhattacharyya

Pre-requistes :
MA 219, MA 222, MA 223 and MA 224

References :
1. Douglas, Ronald G. Banach algebra techniques in operator theory. Second edition. Graduate Texts in Mathematics, 179. Springer-Verlag, New York, 1998. xvi+194 pp. ISBN: 0-387-98377-5.

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.

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.

Pre-requistes : None

References :

PH 202 (JAN) 3 : 0

Statistical Mechanics

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

Sriram Ramaswamy

Pre-requistes : None

References : Pathria, R.K., Statistical Mechanics, Butterworth Heinemann,Second Edn, 1996,Reif, F., Fundamentals of Statistical and Thermal Physics, McGraw Hill, 1965.,Landau, L.D., and Lifshitz E.M., Statistical Physics, Pergamon, 1980.

PH 203 (AUG) 3 : 0

Quantum Mechanics-I

Historical foundations. Wave function for a single particle. Hamiltonian. Schrodinger equation. Probability current. Wave packets. One-dimensional problems: step, barrier and delta-function potentials. Tunnelling, scattering and bound states. Harmonic oscillator, operator approach. Matrix formulation of quantum mechanics. Hermitian and unitary operators. Orthonormal basis. Momentum representation. Uncertainty relations. Postulates of quantum mechanics. Heisenberg representation. Ehrenfest's theorem. 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.

Pre-requistes : None

References : None

PH 204 (JAN) 3 : 0

Quantum Mechanics II

Time dependent perturbation theory. Fermi golden rule. Transitions caused by a periodic external field. Dipole transitions and selection rules. Decay of an unstable state. Born cross section for weak potential scattering. Adiabatic and sudden approximations. WKB method for bound states and tunneling. Scattering theory: partial wave analysis, low energy scattering, scattering length, Born approximation, optical theorem, Levinson's theorem, resonances, elements of formal scattering theory. Minimal coupling between radiation and matter, diamagnetism and paramagnetism of atoms, Landau levels and Aharonov-Bohm effect. Addition of angular momenta, Clebsch Gordon series, Wigner Eckarttheorem, Lande's g factor. Many particle systems: identity of particles, Pauli principle, exchangeinteraction, bosons and fermions. Second quantization, multielectron atoms, Hund's rules. Binding of diatomic molecules. Introduction to Klein Gordon and Dirac equations, and their nonrelativistic reduction.

Subroto Mukerjee

Pre-requistes : None

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

PH 205 (AUG) 3 : 0

Math Methods of Physics

Pre-requistes : None

References :

Linear vector spaces, linear operators and matrices, systems of

PH 206 (JAN) 3 : 0

Electromagnetic Theory

Laws of electrostatics and methods of solving boundary value problems. Multi-pole expansion of electrostatic potentials, spherical harmonics. Electrostatics in material media, dielectrics. BiotSavart Law, magnetic field and the vector potential. Faraday's Law and time varying fields. Maxwell's equations, energy and momentum of the electromagnetic field, Poynting vector,conservation laws. Propagation of plane electromagnetic waves. Radiation from an accelerated charge, retarded and advanced potentials, Lienard-Wiechert potentials, radiation multi-poles. Special theory of relativity and its application in electromagnetic theory. Maxwell's equations in covariant form:four – potentials, electromagnetic field tensor, field Lagrangian. Elements of classical field theory, gauge invariance in electromagnetic theory.

Prasad Satish Hegde

Pre-requistes : None

References : Jackson, J.D., Classical Electrodynamics, Third Edn, John Wiley.,Panofsky, W.K.H., and Phillips, M., Classical Electricity and Magnetism, Second Edn, Dover,Jackson, J.D., Classical Electrodynamics, Third Edn, John Wiley.

PH 207 (JAN) 1 : 2

Electronics I

Basic diode and transistor circuits, operational amplifier and applications,active filters, voltage regulators, oscillators, digital electronics, logic gates, Boolean algebra, flip-flops, multiplexers, counters, displays, decoders, D/A, A/D. Introduction to microprocessors.

Atanu Kumar Mohanty

Pre-requistes : None

References : Horowitz and Hill, The Art of Electronics, Second Edn.,Millman and Halkias, Integrated Electronics, McGraw Hill.,Horowitz and Hill, The Art of Electronics, Second Edn.

PH 208 (JAN) 3 : 0

Condensed Matter Physics-I

Drude model, Sommerfeld model, crystal lattices, reciprocal lattice, X- ray diffraction, Brillouin zones and Fermi surfaces, Bloch's theorem, nearly free electrons, tight binding model, selected band structures, semi-classical dynamics of electrons, measuring Fermi surfaces, cohesive energy, classical harmonic crystal, quantum harmonic crystal, phonons in metals, semiconductors, diamagnetism and paramagnetism, magnetic interactions.

Anindya Das

Pre-requistes : None

References : Ashcroft,N.W.,and Mermin,N.D.,Solid State Physics

PH 211 (AUG) 0 : 3

General Physics Laboratory

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

Pre-requistes : None

References : None

PH 212 (JAN) 0 : 3

Experiments in Condensed Matter Physics

Stirling Engine
Thinfilm deposition by thermal evaporation technique
Low temperature measurement (using closed cycle Helium cryostat)
Scanning Tunneling Microscopy
Atomic Force Microscopy
Franck-Hertz Experiment
Laue Pattern of Single Crystal
Semiconductor Thermogenerator (Peltier and Seebeck effect)
Alpha Scattering
Lock-in Amplifier

Victor Suvisesha Muthu D

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.

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

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.

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

Pre-requistes : None

References : None

PH 250A (JAN) 0 : 6

Project I

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

Subroto Mukerjee

Pre-requistes : None

References : None

PH 250B (AUG) 0 : 6

Project - II

Pre-requistes : None

References : None

PH 300 (AUG) 1 : 0

Seminar Course

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

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.

Pre-requistes : None

References : None

PH 340 (JAN) 3 : 0

Quantum Statistical Field Theory

Vijay B Shenoy

Pre-requistes : None

References : None

PH 351 (AUG) 3 : 0

Crystal Growth, Thin films and Characterization

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

Pre-requistes : None

References : None

PH 352 (AUG) 3 : 0

Semiconductor Physics

Semiconductor fundamentals: band structure, electron and hole statistics,intrinsic and extrinsic semiconductors, energy band diagrams, drift-diffusion transport, generation - recombination, optical absorption and emission. Basic semiconductor devices: on junctions, bipolar transistors, MOS capacitors,field-effect devices, optical detectors and emitters. Semiconductor technology: fundamentals of semiconductor processing techniques; introduction to planar technology for integrated circuits.

Ramesh Chandra Mallik

Pre-requistes : None

References : Seeger, K., Semiconductor Physics, Springer-Verlag, 1990.,Sze, S.M., Physics of Semiconductor Devices, Wiley, 1980.,Muller, K., and Kamins, T., Device Electronics for Integrated Circuits, John Wiley,1977.

PH 354 (JAN) 3 : 0

Computational physics

Introduction to computational physics; Machine representation, precision and errors; Roots of equations; Quadrature; Random numbers and Monte- Carlo Fourier methods Ordinary differential equations Numerical Linear algebra.

Manish Jain

Pre-requistes : None

References : Mark Newman, Computational Physics, Createspace Independent Publishing (2015).,Rubin H. Landau, Manuel J. Paez and Cristian Bordeianu, Computational Physics,3rd Ed Problem Solving with Python, Wiley (2015).,A. Klein and A. Godunov,Introductory Computational Physics, Cambridge University Press (2006),Forman Acton,Real computing made real: Preventing Errors in Scientific and

PH 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

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.

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.

Pre-requistes : None

References : None

PH 364 (JAN) 3 : 0

Topological Phases of Matter (Theory and experiment)

The course is designed to teach the concepts and methods of various forms of topological phases of matter to mainly physics students. Some related concepts and their extensions such as Aharonov-Bohm effect, Berry phase, graphene,Majorana, Weyl fermions will also be taught. This is a combined theory and experimental course (no experiment will however be performed). Students are expected to have taken condensed matter I, but no prior knowledge of group theory is required.

Tanmoy Das

Pre-requistes : None

References : None

PH 365 (JAN) 3 : 0

Galaxies and Interstellar Medium

Galactic structure: local and large scale distribution of stars and interstellar matter, the spiral structure, the galactic centre. Galactic dynamics, stellar relaxation, dynamical friction, star clusters, density wave theory of galactic spiral structure, chemical evolution in the galaxy, stellar populations. Galaxies, morphological classification of galaxies, active galaxies, clusters of galaxies, interactions of galaxies, dark matter,evolution of galaxies.

Prateek Sharma

Pre-requistes : None

References : Mihalas, D. and Binney, J.: Galactic Astronomy.,Binney, J. and Tremaine, S.:Galactic Dynamics,Spitzer, L.: Physical Process in the Interstellar Medium.

PH 371 (JAN) 3 : 0

General Relativity & Cosmology

Foundations of general relativity. Elements of tensor analysis. Schwarzschild and Kerr spacetimes. Black hole physics. Gravitational radiation. Cosmological models. Observational tests. The early universe. The microwave background. Formation of structures.

Rajeev Kumar Jain

Pre-requistes : None

References : Landau, L.D., and Lifshitz, E.M.: The Classical Theory of Fields.,Weinberg, S.: Gravitation and Cosmology.,Peebles, P.J.E.: Physical Cosmology.

PH 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

Pre-requistes : None

References : None

PH 377 (JAN) 2 : 0

Astronomical Techniques

Radio: coordinate system, detection principles, resolution and sensitivity,interferometry and aperturesynthesis. IR/Optical/UV: CCD fundamentals, imaging systems, point-spread-function, sensitivity, photometry and spectroscopy,speckle techniques, adaptive optics. X- ray/Gamma-ray astrophysics: detection principles, detectors and imaging systems, resolution and sensitivity,detector response, data analysis methods for spectroscopic and timing studies. Coordinated laboratory / data analysis exercises in each of the three areas.

Nirupam Roy

Pre-requistes : None

References : Christianson, W.N., & Hogbohm, J.A.: Radio Telescopes Roy, A.E., & Clarke, D.:Astronomy Principles and Practice.,Kitchin, C.R.: Astrophysical Techniques.,G.F.Knoll;, Radiation Detection and Measurement (2nd ed), Wiley, NY N.Tsoulfanidis, Measurement and Detection of Radiation (2nd ed), Taylor &Francis, Washington DC

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

Pre-requistes :
Basic understanding of electromagnetic theory, quantum mechanics and solids

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

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.

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.

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.

Pre-requistes : None

References :

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

QT 211 (AUG) 1 : 2

Basic Quantum Technology Laboratory

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

Pre-requistes : None

References :

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

QT 204 (JAN) 3 : 0

Introduction to Materials for Quantum Technologies

Recap of basic solid-state physics: Electronic band structure; Phonon- band structure, electron-phonon interactions, electron transport and modeling in nanoscopic devices Topology and Quantum Devices: Semiconductor heterostructures, Two dimensional electron systems, Topological materials, Introduction to Superconductivity Correlations and disorder: Electron-electron interactions, Peierls distortion and transition,Disorder physics,Anderson’s localization, Quantum devices through correlations,Magnetic materials, Dielectric materials and ferroelectrics, phase transitions Optics and optical materials: Light-Matter Interaction,introduction to nonlinear optical materials, Optical properties of semiconductors and metals,properties of nanostructured materials, plasmonics.

Chandni U , Navaneetha Krishnan Ravichandran , Pavan Nukala

Pre-requistes :

Basic Quantum Mechanics/Solid state physics, Preliminary course

References : Solid State Physics by N. Aschcroft and N. D. Mermin Electrons and Phonons: The Theory of Transport Phenomena in Solids by J.Ziman Electronic Processes in Non-Crystalline Materials by N. F.Mott and E. A. Davi.

QT 306 (JAN) 3 : 0

Advanced Quantum Computation and Information

Algorithms for noisy intermediate scale quantum systems;Variational techniques, approximation methods; Sampling and classification problems, machine learning; Quantum error correction; Stabiliser codes, topological codes; Quantum hardware platforms: NMR, superconducting transmons, atom and ion traps, quantum dots and impurities, quantum photonics.

Apoorva Patel

Pre-requistes :
Introduction to Quantum Computation (QT 207)

References : Nielsen M.A. and Chuang I.L., Quantum Computation and Information, Cambridge University Press, 2000. Preskill J., Lecture Notes for the Course on Quantum Computation, http://www.theory.caltech.edu/people/preskill/ph229

QT 299 (JAN) 0 : 20

Project

Introduction to Classical Measurement, Introduction to quantum mechanics through measurement, the quantum measurement postulate and its consequences, standard quantum limits (SQL), types of measurements – direct and indirect measurements, orthogonal, non-orthogonal, quantum non-demolition measurements, linear measurements and amplification, beyond the SQL - parametric amplification. Case studies of measurement – quantized charge measurement, single photon detection, non-demolition method for photon quadrature measurements etc. Control of single quantum systems, introduction to decoherence – decoherence as measurement by environment, characterizing decoherence in qubits, openloop control and stabilization of qubit states. Project

Baladitya Suri

Pre-requistes : None

References : Quantum Measurement by Braginsky and Khalili Quantum measurement by Wiseman and Milburn Mechanics by Landau-Lifshitz.

QT 202 (JAN) 3 : 0

Introduction to Quantum Measurement

Introduction to Classical Measurement, Introduction to quantum mechanics through measurement, the quantum measurement postulate and its consequences, standard quantum limits (SQL), types of measurements – direct and indirect measurements, orthogonal, non-orthogonal, quantum non-demolition measurements, linear measurements and amplification, beyond the SQL - parametric amplification. Case studies of measurement – quantized charge measurement, single photon detection, non-demolition method for photon quadrature measurements etc. Control of single quantum systems, introduction to decoherence – decoherence as measurement by environment, characterizing decoherence in qubits, openloop control and stabilization of qubit states.

Baladitya Suri

Pre-requistes :
None.

References : Quantum Measurement by Braginsky and Khalili Quantum measurement by Wiseman and Milburn Mechanics by Landau-Lifshitz.

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.

Pre-requistes : None

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

Mathematical Science_Int PhD

Preface