## Scheme of Instruction 2019-20

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## Division of Interdisciplinary Research

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Preface

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

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

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

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.

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

31st July 2019

Prabhu R Nott
Chair, Senate Curriculum Committee
Division of Biological Sciences

Preface:

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

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

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

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

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

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

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

The research interests in the Centre for Neuroscience spans from molecules to behavior. The courses offered would enable the students to gain fundamental knowledge in molecular and cellular neuroscience, systems and cognitive neuroscience. In addition, students will be expected to actively participate in seminars, journal clubs and lab rotations.
The Centre for Infectious Disease Research (CIDR) is involved in two primary activities: First, providing the intellectual and infrastructural support for infectious disease research. Second, enable researchers to perform studies in the Bio-safety Level-3 (BSL-3) facility, a state-of-the-art bio-containment space to perform research with high infectious organisms, e.g. Mycobacterium tuberculosis etc.

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

Prof. Umesh Varshney
Chairman, Division of Biological Sciences
Integrated PhD (Biological Sciences)

Course Work:

Core Courses: 19 credits

- DB 201 2:0 Mathematics and Statistics for Biologists
- DB 202 2:0 General Biology
- DB 207 0:5 Laboratory
- BC 203 3:0 General Biochemistry
- MB 201 2:0 Biophysical Chemistry
- MC 203 3:0 Microbiology
- RD 201 2:0/
- DB 204 Genetics

Projects: 16 Credits:

- DB 212 0:4 Project - I
- DB 225 0:6 Project - II
- DB 327 0:6 Project - III

Elective Courses: 29 Credits
(For a total of 64 credits)
Biological Science

**DB 201 (AUG) 2:0**
Mathematics and Statistics for Biologists


Sekar K, Supratim Ray, Anand Srivastava

Pre-requisites:
- Biological Instructor, Biological Instructor, Biological Instructor

**DB 202 (AUG) 2:0**
GENERAL BIOLOGY

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

Renee M Borges

References:
- Bonner, J. T. Why Size Matters: From Bacteria to Blue Whales

**DB 203 (AUG) 3:0**
General Biochemistry


Sathees C. Raghavan, Patrick D Silva, Ganesh Nagaraju, Purusharth Rajyaguru

References:

**DB 225 (AUG) 0:6**
Project - II

Utpal Tatu, Dipshikha Chakravortty
An independent research project to be conducted in the laboratory of a faculty member in the Division of Biology. It is desirable that the project be carried out in the laboratory where Project II was conducted.

Dipshikha Chakravortty
Dept of Biochemistry

BC 201 (AUG) 2:0
Cell Biology

Utpal Tatu, Dipankar Nandi, Shikha Laloraya, Patrick D Silva

Pre-requisites:

BC 202 (AUG) 2:0
Proteins: Structure and Function

Narasimha Rao D, Utpal Tatu, Nagasuma R Chandra

Pre-requisites:

BC 203 (AUG) 3:0
General Biochemistry

Sathees C. Raghavan, Patrick D Silva, Ganesh Nagaraju, Purusharth Rajyaguru

Pre-requisites:

BC 306 (AUG) 3:0
Essentials in Immunology
Adaptive and innate immunity, inflammation, antibody structure and function, the complement system, antigen - antibody interaction, cells and organs of the immune system, B cell activation, immunoglobulin genes, molecular basis of antibody diversity, T cell receptors, T cell activation, major histocompatibility complex, antigen processing and presentation, lymphokines, transcription factors, hypersensitivity, autoimmunity, immunological techniques. Immunological disorders and therapy
Dipankar Nandi, Sathees C. Raghavan, Sandeep M Eswarappa

**Pre-requisites:**
- Goldsby,R.A.,Kindt,T.J.,Osborne

**BC 205 (JAN) 2:0**

**Fundamentals of Physiology and Medicine**

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

Sandeep M Eswarappa, Ramray Bhat

**References:**
- 4. Davidson's Principles and Practice of Medicine

**BC 207 (JAN) 2:0**

**Proteomics in Practice**

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 and SILAC).

Utpal Tatu

**Pre-requisites:**
- Reiner Westermeier,Tom Nave,Proteomics :,Tools for the New Biology,by Daniel C Liebler

**BC 209 (JAN) 2:0**

**Dessertation Project**

The dissertation project is aimed at training students to review recent literature in specialized areas of research.students to review recent lit

Jayabaskaran C

**Pre-requisites:**
- Only BC Students,Biochemistry students,Biochemistry students

**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
BC 302 (JAN) 3:0

Current Trends in Drug Discovery


Nagasuma R Chandra

References:
- Principles of Regenerative Biology by Bruce Carlson
- Handbook of the Biology of Ageing, Seventh Edition, by Edward J Masoro (Editor), Steven N. Austad (Editor) 2010

BC 302 (MAY) 3:0

Current Trends in Drug Discovery


Nagasuma R Chandra

Pre-requisites:
- 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
Centre for Ecological Sciences

EC 301 (AUG) 2:1
Animal Behaviour: Mechanisms and Evolution

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

Rohini Balakrishnan, Maria Thaker

References:

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 scents and pollen chemistry; stable isotopes in the study of plant–animal interactions; mate choice in plants; evolution of floral and fruit traits; phenotypic plasticity and inducible defenses in plants; behavioural and physiological processes in generalist and specialist herbivores, pollinators and seed dispersers; co-evolutionary dynamics of symbiosis, mutualisms and arms races

Renee M Borges

Pre-requisites:

EC 303 (AUG) 2:1
Stochastic and Spatial Dynamics in Biology

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

Vishwesha Guttal

References:
• Murray, Mathematical Biology, Springer (Ed 3 in 2002), 978-1-4757-7709-3

Pre-requisites:
• EC 201
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

Kavita Isvaran

References:
• Zuur A, Ieno EN and GM Smith 2007 Analysing ecological data. Springer
• Crawley MJ 2007 The R Book. John Wiley & Sons

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-requisites:

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, Kartik Sunagar

References:

EC 205 (JAN) 2:0
Multi-omics approaches for biologists

Historically, data collection, particularly at the molecular level, has presented the major bottleneck for the advancement of science. For example, in the early years of DNA sequencing technologies, human genome sequencing incurred expenses in billion US dollars and took more than a decade to complete. In contrast, in the modern era of ‘omics’ technologies, sequencing of a human genome costs less than $1000 and a day for sequencing to assembly. The advent of high-throughput technologies has, similarly, revolutionized numerous fields of biology. ‘Big data’ generated by these approaches offers various opportunities and challenges alike. This course will provide an in-depth knowledge of principles and state-of-the-art practices in ‘omics’ approaches and their application in various fields of biology, including ecology, evolutionary biology, genetics, and biomedical research. This course will consist of lectures,
discussions, and hands-on bioinformatic practical sessions, which will introduce students to various aspects of data acquisition, processing, and analyses.

**Kartik Sunagar**

**References:**
- Bioinformatics and Functional Genomics, Pevsner (3rd edition)
- Practical Computing for Biologists, Haddock and Dunn

**Pre-requisites:**
- None

**EC 309 (JAN) 2:0**

**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**

**References:**

**Pre-requisites:**
- EC203

**Co-requisites:**
- None
Molecular Biophysics Unit

**MB 201 (AUG) 2:0**

**Introduction to Biophysical Chemistry**

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

**Raghavan Varadarajan**

Pre-requisites:
- Tinoco, I., Sauer, K., Wang

**MB 204 (AUG) 3:0**

**Molecular Spectroscopy and its Biological Applications**

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

**Siddhartha P Sarma, Mahavir Singh**

Pre-requisites:

**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.

**Kaza Suguna, Aravind Penmatsa**

Pre-requisites:
- Buerger, M.J., Elementary Crystallography, Woolfson, M.M.

**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.

**Srinivasan N, Anand Srivastava**

Pre-requisites:
- Ramachandran, G.N., and Sasisekharan, V., Advances in Protein Chemistry
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, ion channels, oscillations, synapses, behavioral neurophysiology; complexities of the mammalian neuron; dendritic structure; dendritic ion channels; active properties of dendrites; dendritic spikes and backpropagating action potentials; heterogeneity, diversity and degeneracy in the nervous system; hippocampus as an ideal system for assessing learning and memory; synaptic plasticity: short-term plasticity, long-term potentiation and depression; mechanisms underlying synaptic plasticity; intrinsic plasticity; mechanisms underlying intrinsic plasticity; issues in the credit-assignment problem on mechanisms behind learning and memory.

Rishikesh Narayanan

References:
• “Rhythms of the Brain” by Gyorgy Buzsaki, Oxford University Press, 2006.

MB 305 (AUG) 3:0

Biomolecular NMR Spectroscopy


Siddhartha P Sarma, Ashok Sekhar

Pre-requisites:
• Protein NMR Spectroscopy: Principles and Practice, Authors - Cavanaugh,J.,Fairbrother,W.J.,Palmer
• Fundamentals of Protein NMR Spectroscopy, Authors - Gordon Rule and Kevin Hutchinns
• Spin Dynamics: Basics of NMR, Author - Malcolm H Levitt
• Understanding NMR Spectroscopy, Author - James Keeler

MB 207 (JAN) 2:0

DNA - Protein interaction, Regulation of gene expression, Nanobiology


Dipankar Chatterji
Pre-requisites:
• Lewin, B., Genes X, Oxford., McWright and Yamamoto, Transcriptional Regulations I and II, Cold Spring Harbor, Ptashne, M., A Genetic Switch, Cell Press, Ptaschne and Gann, Genes and Signals, Cold Spring, Harbor Laboratory, Selected papers

MB 208 (JAN) 3:1
Theoretical and Computational Neuroscience

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 organization of sensory systems, receptive field and map modelling. Case studies, computational laboratory and projects

Rishikesh Narayanan, SP Arun

Pre-requisites:

MB 212 (JAN) 2:0
Electron microscopy and 3D image processing for Life Sciences

Objectives and basic working principles of different types of microscopes. Different types of electron microscopes 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. Theoretical, computational and practical aspects of various advanced 3D image processing techniques for all kinds of EM data (Random Conical Tilt Pair, Orthogonal Tilt pair, Single Particle Analysis, Subtomogram averaging). Cryo-EM map interpretation and data analysis, validation, molecular docking (use of Chimera, VMD) and application of Molecular Dynamics Flexible Fitting (MDFF)

Somnath Dutta

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-DNA complexes.

Balasubramaninan Gopal

Pre-requisites:
MC 203 (AUG) 3:0

Essentials in Microbiology

Fascinating world of microbes; Principles of microscopy; Microbial taxonomy, Microbial diversity, evolution and genomes; 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; Bacterial predation, and survival strategies.

Dipshikha Chakravortty, Amit Singh, Samay Ravindra Pande

Pre-requisites:

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

MC 205 (AUG) 2:0

Host-Pathogen interactions - Bacteria, Viruses and Protozoan Parasites

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 pathogenesis; 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.

Vijaya S, Dipshikha Chakravortty, Shashank Tripathi

Pre-requisites:

RNA BIOLOGY


Saibal Chatterjee, Purusharth Rajyaguru, Shashank Tripathi

References:

Pre-requisites:
• Gestland, R. F, Cech, T. R, & Atkins J. F.

Molecular Biology


Nagaraja V, Umesh Varshney, Saibal Chatterjee

Pre-requisites:
• Lewin’s GenesX, Lewin, B., Krebs, J. E.

Principles of Genetic Engineering

Ajit Kumar P, Shashank Tripathi

References:

- Gurbachan S. Miglani, Genome Editing: A Comprehensive Treatise.

Information will also be taken from the original papers, which describe the principles and methods.

Pre-requisites:
- Basic biology, chemistry and physics

Co-requisites:
- None

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; Cell death and protein homeostasis pathways and Cellular diseases.

Methods: Introduction and evolution of light microscopy; Electron microscopy; Cytohistochemistry; Flow cytometry; Pulse-chase and subcellular fractionation; Proteomics and Protein-protein interaction approaches and genome-wide RNAi or small molecular screens to study the various cellular pathways.

Subba Rao Gangi Setty, Sachin Kotak

Pre-requisites:

MC 213 (AUG) 2:0

Laboratory Rotations

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

Amit Singh

MC 202 (JAN) 2:0

Developmental Genetics

Logic and techniques of molecular genetic analysis. Understanding interaction networks using genetics and genomics, Illustrating the application of genetic analysis to specific developmental pathways in model eukaryotes and prokaryotes. Some examples are genetic and epigenetic mechanisms of cell fate determination and signaling pathways in development, embryo and organ patterning, regulation of organ size and shape, stem cell homeostasis and developmental plasticity using Drosophila and Arabidopsis.
as model organisms. Development in unicellular prokaryotes and eukaryotes. Genetics of the evolution of life cycle in the lab.

Utpal Nath, Upendra Nongthomba, Samay Ravindra Pande

References:
• 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

MC 210 (JAN) 2:0

Molecular Oncology


Kumaravel Somasundaram, Annapoorni Rangarajan

References:

MC 211 (JAN) 2:0

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

Varsha Singh, Purusharth Rajaguru, Nagalingam Ravi Sundaresan

References:
• Regeneration – Developmental Biology by Scott F Gilbert (6th edition)
• Molecular Biology of Aging (Cold Spring Harbor Monograph Series)
Dept of Molecular Reproduction Development and Genetics

**RD 201 (AUG) 2:0**

**Genetics**

Transmission and distribution of genetic materials, dominance relations and multiple alleles, gene interaction and lethality. Sex linkage, maternal effects and cytoplasmic heredity, cytogenetics and quantitative inheritance. Elements of developmental and population genetics.

**Mahadevan S, Srimonta Gayen**

**Pre-requisites:**
- Genetics 3rd edition by M. Strickberger
- Molecular Genetics 2nd edition by G. Stent and R. Calendar
- Genetic Switch 2nd edition by M. Ptashne

**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 i GPCRs 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 how spatio-temporal dynamics of signaling pathways regulate cellular physiology. Genetic analysis of signalling pathways in model organisms.

**Deepak Kumar Saini, Ramray Bhat**

**Pre-requisites:**
- Molecular Biology of the Cell by Alberts B et al., 5th Edition

**RD 210 (AUG) 2:0**

**Fundamentals of Physiology and Medicine**

**Ramray Bhat**

**RD 206 (JAN) 2:0**

**Molecular Oncology**

Kumaravel Somasundaram, Annapoorni Rangarajan

References:

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

References:

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.

Sandeep M Eswarappa, Ramray Bhat

References:
Centre for Neuroscience

**NS 201 (AUG) 2:0**

**Systems Neuroscience**

Neuronal biophysics, sensation & perception, motor systems

Aditya Murthy, SP Arun, Supratim Ray

**NS 202 (AUG) 2:0**

**Molecular and Cellular Basis of Behaviour**

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

Balaji J, Deepak Kumaran Nair

**NS 203 (AUG) 2:0**

**Cognitive Neuroscience**

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

Sridharan Devarajan, srikant Padmala

**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.

Narendrakumar Ramanan, Kavita Babu

**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

**NS 301 (JAN) 2:0**
**Topics in Systems and Cognitive Neuroscience**

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

SP Arun, Supratim Ray, Srikant Padmala

Pre-requisites:
- NS201 or NS203

**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, Narendra Kumar Ramanan, Deepak Kumaran Nair

Pre-requisites:
- NS202 or NS204
Division of Chemical Sciences

Preface:

The division of Chemical Sciences comprises of the departments of Inorganic and Physical Chemistry (IPC), Materials Research Centre (MRC), NMR Research Centre (NRC), Organic Chemistry (OC) and Solid State and Structural Chemistry Unit (SSCU). Students with a basic/advanced degree in Chemistry, Physics or several branches of engineering are eligible for admission to the doctoral program in the division. 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 PhD
- 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 several 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 different streams at the Institute. For details concerning these requirements, students are advised to approach the department Chairman or the Departmental Curriculum Committee.

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.
The NMR Research Centre houses several modern NMR spectrometers; courses are offered at various levels, both on basic and advanced topics. In addition, the center also organizes workshops and symposia in the area of Nuclear Magnetic Resonance. In addition, it provides research facilities in the area of NMR to scientists from all over the country.

Prof. P K Das,
Chairman
Division of Chemical Sciences
Integrated PhD (Chemical Sciences)

Course Work:

Core Courses

I Semester
CD 204 3:0  Chemistry of Materials
CD 211 3:0  Physical Chemistry-I
CD 212 3:0  Inorganic Chemistry
OC 213 3:0  Organic Chemistry
CD 214 3:0  Basic Mathematics
CD 215 0:4  General Chemistry Lab. (Organic & Inorganic)

II Semester
CD 221 3:0  Physical Chemistry II
CD 222 3:0  Material Chemistry
CD 223 3:0  Organic Synthesis
CD 224 2:1  Computers in Chemistry
CD 225 0:4  Physical and Analytical

Chemistry Lab

III Semester (optional)
16 Credits of optional courses to be taken from any of the five Departments in consultation with the Ph. D. Supervisor.

IV Semester
CD 241 : 0:14 Research Project Six credits of optional courses in consultation with Ph. D. Supervisor.
Chemical Science

CD 204 (AUG) 3:0
Chemistry of Materials
Aspects of crystal chemistry (lattices, unit cells, symmetry, point groups and space groups etc), packing, bonding and description of crystal structures, Pauling rules, crystallographic methods, defects in solids, electronic structure, magnetism, phase transitions, framework solids, ionic solids and synthesis of solids

Vasudevan S, Natarajan S

References:

CD 211 (AUG) 3:0
Physical Chemistry – I Quantum Chemistry and Group Theory
Postulates of Quantum Mechanics and introduction to operators; Wave Packets, Exactly solvable problems Perturbational, Variational, and WKB Methods; Angular Momentum and Rotations, Hydrogen Atom, Zeeman and Stark effects, Many electron Atoms, Slater determinants, Hartree-Fock Variational Method for atoms; Symmetry and Group theory, Point Groups, Reducible and Irreducible Representations (IR), Great Orthogonality theorem, Projection operators, Applications to molecular orbitals and normal modes of vibration and selection rules in spectroscopy

Ramasesha S, Sarma D D

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

CD 212 (AUG) 3:0
Inorganic Chemistry – Main group and coordination chemistry
Main group: hydrogen and its compounds – ionic, covalent, and metallic hydrides, hydrogen bonding; chemistry of lithium, beryllium, boron, nitrogen, oxygen and halogen groups; chains, rings, and cage compounds; Coordination chemistry: bonding theories (revision and extension), spectral and magnetic properties; inorganic reactions and mechanisms: hydrolysis reactions, substitution reactions trans-effect; isomerization reactions, redox reactions; metal-metal bonding and clusters; mixed valence systems; chemistry of lanthanides and actinide elements

Jemmis E. D, Abhishake Mondal

References:
- Shriver D.F, Atkins P.W. and Langford C.H., Inorganic Chemistry, Freeman, NY

CD 213 (AUG) 3:0
Organic Chemistry – Structure and Reactivity
Stereochemistry and conformational analysis. Methods of deducing organic reaction mechanisms, Hammond postulate, Curtin-Hammett principle, linear free energy relationships; Hammett equation; kinetic isotope effects. Electronic effects in organic compounds, aromaticity, frontier orbital theory, steric effects; organic transformations and molecular rearrangements; reactive intermediates, classical and nonclassical carbocations, carbanions, free radicals, carbenes, nitrenes, arynes, radical ions, diradicals, concerted reactions, Woodward-Hoffman rules.

Uday Maitra, Mrinmoy De

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

CD 214 (AUG) 3:0
Basic Mathematics

Suryaprakash N, Hanudatta S Atreya

References:
- Thomas, G. B., Finney, R. L., Calculus and Analytical Geometry

CD 215 (AUG) 0:4
Organic & Inorganic Chemistry Laboratory
Common organic transformations such as esterification, Diels-Alder reaction, oxidation-reduction, Grignard reaction, etc. Isolation and purification of products by chromatographic techniques, characterization of purified products by IR and NMR spectroscopy. Synthesis of coordination complexes, preparation of compounds of main group elements, synthesis of organo-metallic complexes. Physico-chemical characterization of these compounds by analytical and spectroscopic techniques.

Erode N Prabhakaran, Abhishake Mondal

CD 402 (AUG) 3:0
Molecular Spectroscopy, Dynamics and Photochemistry
Energy levels of molecules and their symmetry. Polyatomic rotations and normal mode vibrations. Electronic energy states and conical intersections; time-dependent perturbation theory and selection rules; microwave, infrared and Raman, electronic spectroscopy; energy transfer by collisions, both inter and intra-molecular. Unimolecular and bimolecular reactions and relations between molecularity and order of reactions, rate laws; temperature and energy dependence of rate constants, collision theory and transition state theory, RRKM and other statistical theories; photochemistry, quantum yield, photochemical reactions, chemiluminescence, bioluminescence, kinetics and photophysics.

Arunan E
CD 221 (JAN) 3:0
Physical Chemistry II: Statistical Mechanics


Govardhan P Reddy

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


Karuna Kar Nanda, Prabeer Barpanda

References:
- A.R. West, Solid State Chemistry and its Applications
- J.F. Shackelford, Introduction to Materials Science for Engineers

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.

Tushar Kanti Chakraborty, Akkattu T Biju

References:
- Cambridge University Press, 1986
- House, Modern Synthetic Reactions, 1972

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

References:
- Any accessible book on numerical methods,
Physical and Analytical Chemistry Laboratory

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

Shivakumara C, Chinmoy Ranjan

References:

Research Project

Ravishankar Narayan

Advanced NMR Spectroscopy

Basic principles of two-dimensional (2D) NMR spectroscopy, 2D line shapes, phases and filtering. Resolved 2D spectroscopy. Correlated 2D experiments (COSY, TOCSY, etc.) involving homo-nuclear and hetero-nuclear correlations. 2D multiple-quantum spectroscopy, 2D relaxation experiments (NOESY, ROESY). Multinuclear 2D and 3D experiments such as HSQC, HMQC, HNCA and HNCA (CO) etc. Introduction to coherence level diagram, product operator formalism, phase cycling and gradient-enhanced spectroscopy. Two-dimensional NMR of solids. NMR imaging. Applications of two and three-dimensional NMR experiments for structure determination of large molecules.

Suryaprakash N, Hanudatta S Atreya

References:
(a) W. R. Croasmun and R. M. K. Carlson, Two -Dimensional NMR Spectroscopy - Applications for Chemists and Biochemists, VCH, 1987.,...
**IP 203 (AUG) 3:0**

**Group Theory and Molecular Spectroscopy**


**Atanu Bhattacharya**

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

**IP 214 (AUG) 2:1**

**Crystallography for Chemists**


**Nethaji M**

**References:**
- C. A. Taylor, A nonmathematical introduction to X-ray diffraction
- G. Stout and L. H. Jensen, X-ray structures determination
- 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.

**Mugesh G**

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

Samuelson A G

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

Physical Principles of Chemistry

Vasudevan S, Upendra Harbola

Ultrafast Optics and Spectroscopy in Physical Chemistry


Atanu Bhattacharya

References:
• Andrew Weiner, Ultrafast Optics (Wiley)
• Rick Trebino, Ultrafast Optics (Online Book, Georgia Institute of Technology)
• Robert Guenther, Modern Optics (John Wiley and Sons)
• Grant R. Fowles, Introduction to Modern Optics (Dover Publications)

Spectroscopy and Astrochemistry


Arunan E
IP 322 (JAN) 3:0

Polymer Chemistry


Ramakrishnan S

References:
• Flory P.J., Principles of Polymer Chemistry
• Odian G., Principles of Polymerization
• Paul C Hiemenz and Timothy P Lodge, 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

References:
• E. Gileadi, Electrode Kinetics for Chemists, Chemical Engineers and Material Scientists (VCH 1993)
• C. A. Vincent, Modern Batteries (Edward Arnold, UK 1984)
Materials Research Centre

MR 303 (AUG) 3:0
Nanomaterials Synthesis and Devices
Introduction to nanoscience and nanotechnology. Surfaces, interfaces and characterization techniques. Chemical and physical methods of synthesizing nanomaterials (0D, 1D & 2D), Growth mechanisms and growth kinetics, Size-dependent properties of nanomaterials, Applications in catalysis, gas sensing, photodetection and white light emission, Applications in Devices such as linear, rectifier, FET, etc.

Karuna Kar Nanda, Balaram Sahoo

References:
• Markov I. V., Crystal Growth for Beginners, Fundamentals of Nucleation, Crystal Growth and Epitaxy, World Scientific

MR 304 (AUG) 1:2
Characterization Techniques in Materials Science
Preparation of fine particles, growth of single crystals and thin films, thermal analysis, magnetic measurement, X-ray diffraction, SEM and TEM analyses, electrical and dielectric measurements.

Arun M Umarji

Pre-requisites:
• Faculty of MRC

MR 222 (JAN) 3:0
Chemistry of Materials

Karuna Kar Nanda, Prabeer Barpanda

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

MR 305 (JAN) 3:0
Functional Dielectrics
Physical and mathematical basis of dielectric polarization, polarization in static/alternating electric fields. Conductivity and loss. piezoelectric, pyroelectric and ferroelectric concepts. Ferroic materials, primary and secondary ferroics, Optical materials. Birefringence and crystal structure, electro-optic materials and light modulators

Balaram Sahoo

References:
MR 306 (JAN) 3:0

Electron Microscopy in Materials Characterization


Ravishankar Narayanan

References:

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

References:
Organic Chemistry

CD 213 (AUG) 3:0

Organic Chemistry – Structure and Reactivity

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

Uday Maitra, Mrinmoy De, Garima Jindal

Pre-requisites:
- Anslyn

OC 203 (AUG) 3:0

Organic Chemistry-I

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

Uday Maitra, Mrinmoy De, Garima Jindal

Pre-requisites:
- Anslyn, E.V., and Dougherty, D.A., Modern

OC 231 (AUG) 3:0

Chemistry of Proteins and Peptides


Erode N Prabhakaran

References:

OC 301 (AUG) 3:0

Organic Synthesis II

Organic synthesis and total synthesis of complex natural products: Advances in C-C bond forming reactions; Olefination reactions; Olefin metathesis including alkyne metathesis; Synthesis of alkynes;
Asymmetric addition of Grignard reagents, organozinc and lithium reagents to carbonyl compounds; Directed lithiation, chiral lithium reagents; alkylation of carbonyl compounds including asymmetric alkylation. Addition of organometallinic reagents to imines, Asymmetric acetate/propionate aldol reaction. Asymmetric alkylation of carbonyl compounds; Ring forming reactions, Baldwin rules; cyclopentannulations with specific application to triquinanes. Advances in carbocation rearrangements. Inverse electron demand Diels Alder reaction/ Hetero Diels Alder reaction: Application of the above in the total synthesis of natural products including natural products of contemporary interest in current literature.

Kavirayani R Prasad

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

OC 302 (AUG) 3:0
Asymmetric Catalysis: From Fundamentals to Frontiers

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

Santanu Mukherjee

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 polysaccharides, glycoproteins, proteoglycans and glycosaminoglycans; selected natural product synthesis originating from a sugar scaffold

References:
• References: Monosaccharides: Their chemistry and their roles in natural products, P. Collins and R. Ferrier, John Wiley & Sons Ltd., Chichester, 1998. Carbohydrates: The essential molecules of life

OC 232 (JAN) 3:0
Graduate Colloquium

Students will present a short seminar on a selected contemporary topic which would be extremely useful for educating the students beyond their immediate area of interest. This course will be treated as a departmental requirement for all students registered at the Department of Organic Chemistry during the first year.

Santanu Mukherjee, Mrinmoy De
Pre-requisites:
  • colloquium

**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

*Tushar Kanti Chakraborty, Akkattu T Biju*

**References:**

**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 Mass Spectrometry; Circular dichroism, 2D NMR spectroscopy Other physical methods like.

*Prabhu K R*

**References:**
Solid State and Structural Chemistry

CD 204 (AUG) 3:0
Chemistry of Materials

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

Vasudevan S, Natarajan S

References:

CD 211 (AUG) 3:0
Quantum Chemistry and Group Theory

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

Ramasesha S, Sarma D D

CD 221 (AUG) 3:0
Physical Chemistry-2: Statistical Mechanics

Govardhan P Reddy

References:
- Statistical Mechanics by Donald Allan McQuairre
- Statistical Mechanics for Chemistry and Material Science by Biman Bagchi
- Introduction to Modern Statistical Mechanics by David Chandler
- Thermodynamics by Enrico Fermi

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.

Awadhesh Narayan

Pre-requisites:
- H.B. Callen, Thermodynamics and an Introduction to Thermo Statistics, D.A. McQuarrie, Introduction to Statistical Mechanics, D. Chandler
SS 202 (AUG) 3:0
Introductory Quantum Chemistry


Anshu Pandey, Vivek Tiwari

Pre-requisites:
- Ira Levine, Quantum Chemistry, P.W. Atkins, Molecular Quantum Mechanics, A. Szabo and N. Ostlund

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. Basics of neutron diffraction, electron diffraction.

Guru Row T N

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

SS 209 (AUG) 3:0
Electrochemical Systems

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

Naga Phani B Aetukuri

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

Pre-requisites:
- The students need to be comfortable with elementary differential and integral calculus and basics of thermodynamics. A prior exposure to electromagnetism may be useful but not necessary.

SS 304 (AUG) 3:0
Solar Energy: Advanced Materials and Devices

Satish Amrutrao Patil, Anshu Pandey

References:
Division of Physical and Mathematical 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 Rahul Pandit
Chair
Division of Physical & Mathematical Sciences
Dept of Instrumentation and Applied Physics

M Tech in Instrument Technology
Duration: 2 Years
Credits: 64 credits

<table>
<thead>
<tr>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Core courses 21 credits</td>
</tr>
<tr>
<td>Electives 24 credits</td>
</tr>
<tr>
<td>Project 19 credits</td>
</tr>
</tbody>
</table>

Core (21 Credits)

18 credits from the pool below + one 3 credit Mathematics course approved by the Department

IN 214 2:1 Semiconductor Devices and Circuits
IN 227 3:0 Control System Design
IN 229 3:0 Advanced Instrumentation and Electronics
IN 244 2:1 Optical Metrology
IN 222 3:0 Microcontrollers and Applications
IN 228 3:0 Automatic System Control Engineering
IN 267 3:0 Fluorescence Microscopy and Imaging
IN 224 3:0 Nanoscience and Device Fabrication
IN 270 3:0 Digital Signal Processing
IN 232 3:0 Concepts in Solid State Physics
IN 302 3:0 Classical and Quantum Optics

Electives: The balance of 24 credits required to make up a minimum of 64 credits for completing the M Tech Programme.

IN 201 3:0 Analytical Instrumentation
IN 212 3:0 Advanced Nano/Micro Systems
IN 210 3:0 Wave propagation in periodic media
IN 223 3:0 Plasma Processes
IN 234 3:0 High Vacuum Technology and Applications
IN 268 2:1 Microfluidic Devices and Applications.
IN 271 3:0 Cryogenic Instrumentation and Applications

Dissertation Project
IN 299 0:19 Dissertation Project
IN 201 (AUG) 3:0
Analytical Instrumentation
Principles, instrumentation, design and application of UV, visible and IR spectroscopy, mass spectrometry, Mossbauer and NMR spectroscopy, X-ray methods of analysis including powder diffraction, wavelength and energy dispersive X-ray fluorescence. Electron microscopy and microprobe. ESCA and AUGer techniques, photo electron spectroscopic methods, scanning tunneling and atomic force microscopy. Chromatography, thermal analysis including DTA, DSC and TGA. Thermal wave spectroscopic techniques such as photo-acoustic, photo-thermal deflection and photopyro-electric methods.
Asokan S, Siva Umapathy
References:
• Willard,H.W.,Merritt,L.L.,Dean

IN 210 (AUG) 3:0
Wave propagation in periodic media
Theory of one, two and three dimensional lattices, energy velocity, energy flow, characteristics impedance, Kronig-Penny and tight binding models of crystals, wave propagation in nonlinear structures. Transmission and reflection of electromagnetic waves on an interface, grating theory, multi-dimensional phononic and photonic crystals, materials and techniques of fabrication, nature inspired periodic structures, device applications
Abha Misra
References:

IN 221 (AUG) 3:0
Sensors and Transducers
Electromagnetics, Electromagnetic Sensors , Electrical Machines, Semiconductor fundamentals, MOS capacitor based sensors, FET based sensors, Mechatronics, Microelectromechanical system, Mechanical Transducers, Photonics, Imaging Sensors, Fiber optics, interferometry, Measurements on the Micro and Nanoscale, Fundamental limits on amplifiers, Fabrication of sensors, Photolithography
Atanu Kumar Mohanty, Jayanth G R, Sanjiv Sambandan, Manish Arora, Chandni U, Asha Bhardwaj, Dr. Baladitya Suri
References:
• W. Bolton, Mechatronics, Longman, 2015
• B.E.A. Saleh and M.C. Teich , Fundamentals of Photonics, John Wiley and Sons, 2007
• D. Pozar, Microwave Engineering,John Wiley and Sons, 2012
• Robert F. Pierret, Gerold W. Neudeck, Modular Series on Solid State Devices, Pearson, 1988
• M. J. Madou, Fundamentals of Microfabrication, CRC Press, 2002

IN 229 (AUG) 3:0
Advanced Instrumentation Electronics
Instrumentation building blocks: operational amplifiers, RC timers, waveform generators, programmable
analog circuits, analog filter design, switched capacitor circuits, CAD for analog circuits. RF circuits: basic transmission line theory, impedance matching, Smith chart, stability of RF amplifiers, VCO, mixer, PLL. Measurement and characterization of noise.

Atanu Kumar Mohanty

References:
• Horowitz,P.,and Hill,W.,Art of Electronics

IN 232 (AUG) 3:0
Concepts in solid state physics
Vibrations in solids; Electrons in Metals; Phonons; Tight binding chain; Chemical bonding in solids; Crystal structure; Real and Reciprocal Space; Scattering experiments; Waves in reciprocal space; Band structure and optical properties; Fermi surfaces; Introduction to semiconductors; Magnetism; Practical examples and review.

Chandni U

References:
• Steven H. Simon, The Oxford solid state basics, Oxford University Press, 2013
• Aschroft and Mermin, Solid State Physics
Pre-requisites:
• Basic mathematics and Linear Algebra

IN 234 (AUG) 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

References:
• Valery Tuchin, Tissue Optics: Light Scattering Methods and Instruments for Medical Diagnosis, SPIE Press (2007).
Pre-requisites:
• Signals Processing, Optics, & consent from the instructor

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.

Partha Pratim Mondal

Pre-requisites:

IN 270 (AUG) 3:0
Digital Signal Processing
Fourier analysis, Fourier Integral, Discrete Fourier transform multiplications of two signals, Z transform, convolution, correlation Digital filtering, Discrete transformation modulation, FIR, IIR filters, Analog I/O interphase for real time DSP system, application of TMS320 C6713DSK to evaluate convolution, IIR and FIR filter.

Mondal T K
References:
- Ervin Kreszic - Advanced engineering mathematics, Robert F Coughlin., Frederick F driscoll, Operational amplifier and linear integrated circuits., Emmanuel c Ifeachar

IN 302 (AUG) 3:0
Classical and Quantum Optics
Wave Optics and Electromagnetic Theory, Quantum Behaviour of Light, Casimir Effect etc.

Partha Pratim Mondal

IN 212 (JAN) 3:0
Advanced Nano/Micro Systems
Fundamentals of MEMS & NEMS fabrication, Physical properties of MEMS and NEMS devices, doping, pattern generation, tools for nanoscale characterizations, CMOS based devices, Advanced sensing systems such as image sensor, touch sensors, accelerometer, gyroscope, flow sensors, actuators, transducers, thermal sensor, electrostatic, piezoelectric piezoresistive sensors, chemical sensors, biological sensors, strain gauges, load cells, pressure sensors, optical sensors, signal conditioning circuits for sensors, control units etc., electrons and ions optics, single electron tunneling, quantization of electrical conduction, electronic and photonic band gap crystals.

Abha Misra
References:

IN 214 (JAN) 3:0
Semiconductor Devices and Circuits

Sanjiv Sambandan

References:

IN 222 (JAN) 3:0
Microcontrollers and Applications


Ramgopal S

References:

IN 223 (JAN) 3:0
Plasma Processes

Glow discharge plasmas, ion surface interactions, magnetron discharges, ion sources, DC, RF and ECR plasmas, surface modification using ion sources, ion beam mixing and ion implantation, ion beam etching for microelectronic devices, plasma diagnostics, Langmuir probe, glow discharge mass spectrometry and optical emission spectrometry, plasma surface modification.

Mohan Rao G

References:
• Chapman, B.N., Glow Discharge Processes, John Wiely and Sons, 1979.

IN 224 (JAN) 3:0
Nanoscience and Device fabrication

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 self assembled InAs quantum dots, Heterostructures grown inside MBE, FIB for ion implantation and insulation writing, lithography.

Asha Bhardwaj
References:
• Fundamentals of Nanoelectronics by George W. Hanson
• Nanotechnology-understanding small systems by Ben Rogers, Jesse Adams, Sumita Pennathur
• Nanotechnology:Principles and practices by Sulabha Kulkarni

IN 227 (JAN) 3:0
Control Systems Design
Dynamics of linear systems, Laplace transforms, analysis of feedback control systems using Nyquist plots, Bode plots and Root Locus, design of control systems in single-degree of-freedom configuration using direct design, proportional-integral-derivative control, lead-lag compensation, design of control systems in two-degree of-freedom configuration to achieve robustness, Quantitative feedback theory control of non-minimum phase systems, Bode sensitivity integrals, use of describing functions to analyze and compensate nonlinearities.

Jayanth G R
References:

IN 228 (JAN) 3:0
Automatic System Control Engineering

Mondal T K
References:

IN 266 (JAN) 3:0
Introduction to Quantum Measurement and Control
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.

Dr. Baladitya Suri
References:
IN 271 (JAN) 3:0
Cryogenic Instrumentation and Applications

Introduction and fundamentals of cryogenic technology, Properties of cryogenic fluids, Properties of materials at low temperatures, Cryogenic refrigeration systems and gas liquefaction systems, Measurement of temperature, pressure, flow and liquid level, Cryogenic fluid storage and transfer systems, Design of cryostats and cryogenic systems, Cryocoolers, Cryogenic safety, Applications of cryogenics.

Upendra Behera

References:

IN 299 (JAN) 0:19
Dissertation Project
<table>
<thead>
<tr>
<th>Course no.</th>
<th>Credits</th>
<th>Course title</th>
<th>Type</th>
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<tbody>
<tr>
<td>MA 200</td>
<td>3:1</td>
<td>Multivariable Calculus</td>
<td>Core</td>
</tr>
<tr>
<td>MA 212</td>
<td>3:0</td>
<td>Algebra I</td>
<td>Core</td>
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<tr>
<td>MA 219</td>
<td>3:1</td>
<td>Linear Algebra</td>
<td>Core</td>
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<tr>
<td>MA 221</td>
<td>3:0</td>
<td>Analysis I: Real Analysis</td>
<td>Core</td>
</tr>
<tr>
<td>MA 231</td>
<td>3:1</td>
<td>Topology</td>
<td>Core</td>
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<tr>
<td>MA 261</td>
<td>3:0</td>
<td>Probability Models</td>
<td>Core</td>
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<tr>
<td>MA 223</td>
<td>3:0</td>
<td>Functional Analysis</td>
<td>Core</td>
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<tr>
<td>MA 232</td>
<td>3:0</td>
<td>Introduction to Algebraic Topology</td>
<td>Core</td>
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<tr>
<td>MA 242</td>
<td>3:0</td>
<td>Partial Differential Equations</td>
<td>Core</td>
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<tr>
<td>MA 216</td>
<td>3:0</td>
<td>Introduction to Graph Theory</td>
<td>Elective</td>
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<tr>
<td>MA 220</td>
<td>3:0</td>
<td>Representation Theory of Finite Groups</td>
<td>Elective</td>
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<tr>
<td>MA 306</td>
<td>3:0</td>
<td>Topics in Morse Theory</td>
<td>Elective</td>
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<td>MA 328</td>
<td>3:0</td>
<td>Introduction to Several Complex Variables</td>
<td>Elective</td>
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<td>MA 333</td>
<td>3:0</td>
<td>Riemannian Geometry</td>
<td>Elective</td>
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<tr>
<td>MA 341</td>
<td>3:0</td>
<td>Matrix Analysis &amp; positivity</td>
<td>Elective</td>
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<td>MA 349</td>
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<td>Topics around the Grothendieck inequality</td>
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<tr>
<td>MA 361</td>
<td>3:0</td>
<td>Probability Theory</td>
<td>Elective</td>
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<tr>
<td>MA 371</td>
<td>3:0</td>
<td>Control &amp; Homogenization</td>
<td>Elective</td>
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<tr>
<td>MA 395</td>
<td>3:0</td>
<td>Topics in Stochastic Finance</td>
<td>Elective</td>
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<tr>
<td>MA 396</td>
<td>3:0</td>
<td>Large Deviations</td>
<td>Elective</td>
</tr>
<tr>
<td>MA 399</td>
<td>2:0</td>
<td>Seminar on topics in Mathematics</td>
<td>Elective</td>
</tr>
</tbody>
</table>
MA 200 (AUG) 3:1

Multivariable Calculus

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

Kaushal Verma

References:
- B. V. Limaye and S. Ghorpade, A course in Calculus and Real Analysis, Springer
- Spivak, M., Calculus on Manifolds, W.A. Benjamin, co., 1965

MA 212 (AUG) 3:0

Algebra I


Apoorva Khare

References:

Pre-requisites:
- UM 203

MA 216 (AUG) 3:0

Introduction to Graph Theory

Graphs, subgraphs, Eulerian tours, trees, matrix tree theorem and Cayley’s formula, connectedness and Menger’s theorem, planarity and Kuratowski’s theorem, chromatic number and chromatic polynomial, Tutte polynomial, the five-colour theorem, matchings, Hall’s theorem, Tutte’s theorem, perfect matchings and Kasteleyn’s theorem, the probabilistic method, basics of algebraic graph theory.

Arvind Ayyer

References:

Pre-requisites:
- No prerequisites are expected, but we will assume a familiarity with linear algebra.
MA 219 (AUG) 3:1
Linear algebra


Vamsi Pritham Pingali

References:

Pre-requisites:
- UM 102

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 SU(2)

Pooja Singla

References:

Pre-requisites:
- MA 219, MA 212

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.

Gadadhar Misra

References:
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.

Thangavelu S

References:
- John Conway A Course in Functional Analysis (Springer),
- Rajendra Bhatia Notes On Functional Analysis Texts and Readings in Mathematics (Hindustan Book Agency 2009)

Pre-requisites:
- MA 222, MA 224, MA 219

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.

Subhojoy Gupta

References:

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 Homology: Simplicial complexes, chain complexes, definitions of the simplicial homology groups, properties of homology groups, applications.

Siddhartha Gadgil

References:

Pre-requisites:
- MA 231, MA 212
MA 242 (AUG) 3:0  
Partial Differential Equations  
First order partial differential equation and Hamilton-Jacobi equations; Cauchy problem and classification of second order equations, Holmgren’s uniqueness theorem; Laplace equation; Diffusion equation; Wave equation; Some methods of solutions, Variable separable method.  
Thirupathi Gudi  
References:  
• Garabedian, P. R., Partial Differential Equations, John Wiley and Sons, 1964.  
Pre-requisites:  
• MA 241

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.  
Arvind Ayyer  
References:  

MA 306 (AUG) 3:0  
Topics in Morse Theory  
Transversality, Morse functions, stable and unstable manifolds, Morse-Smale moduli spaces, the space of gradient flows, compactification of the moduli spaces of flows, Morse homology, applications.  
Arun Maiti  
References:  
• L. Nicolescu, An invitation to Morse theory, http://www3.nd.edu/$\sim$lnicolae/Morse2nd.pdf.  
• M. Schwarz, Morse homology, Birkhäuser, Basel, 1993.  
• R. Cohen, Kevin Iga, Paul Norbury, Topics in morse theory, lecture notes, 2006.  
Pre-requisites:  
• MA 232, MA 338

MA 328 (AUG) 3:0  
Introduction to Several Complex Variables  
Preliminaries: Holomorphic functions in $\mathbb{C}^n$: definition, the generalized Cauchy integral formula, holomorphic functions: power series development(s), circular and Reinhardt domains, analytic continuation: basic theory and comparisons with the one-variable theory. Convexity theory: Analytic continuation: the role of convexity, holomorphic convexity, plurisub-harmonic functions, the Levi problem.
and the role of the d-bar equation. The d-bar equation: Review of distribution theory, Hormander’s solution and estimates for the d-bar operator.

Gautam Bharali

References:

MA 333 (AUG) 3:0

Riemannian Geometry

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

Ved V Datar

References:
• Peter Petersen, Riemannian geometry, Graduate Texts in Mathematics, 171. Springer-Verlag, New York, 1998.

MA 341 (AUG) 3:0

Matrix Analysis and Positivity

Apoorva Khare

References:

Pre-requisites:
- MA 219

Co-requisites:
- A course in Linear Algebra and Calculus/Real Analysis

MA 349 (AUG) 3:0

Topics around the Grothendieck inequality

Banach-Mazur distance, 2 - summing norm, CUT norm, Tensor product norm (projective and injective), Grothendieck inequality, Operator space structure (MIN and MAX), contractive and completely contractive maps, Applications.

Gadadhar Misra

References:
- Summing and Nuclear Norms in Banach Space Theory, G. J.O. Jameson, London Mathematical Society (Student Texts)
- Completely Bounded Maps and Operator Algebras, V. I. Paulsen, Cambridge University Press
- Alice and Bob Meet Banach: The Interface of Asymptotic Geometric Analysis and Quantum Information Theory, Guillaume Aubrun, Stanislaw J. Szarek, Mathematical Surveys and Monographs Volume: 223; 2017

MA 361 (AUG) 3:0

Probability theory

Probability measures and random variables, pi and lambda systems, expectation, the moment generating function, the characteristic function, laws of large numbers, limit theorems, conditional contribution and expectation, martingales, infinitely divisible laws and stable laws.

Manjunath Krishnapur

References:
- Walsh, J., Knowing the Odds: An Introduction to Probability, AMS, 2012.

Pre-requisites:
- MA 222

MA 371 (AUG) 3:0

Control and Homogenization

Nandakumaran A K

References:

Pre-requisites:
• Sobolev spaces
• Elliptic boundary value problems Heat and wave equations Variational formulation and semigroup theory
• Heat and wave equations
• Variational formulation and semigroup theory

MA 395 (AUG) 3:0

Topics in Stochastic Finance


Mrinal Kanti Ghosh

References:

Pre-requisites:
• MA 261 or equivalent

MA 396 (AUG) 3:0

Large Deviations

Large deviations provide quantitative estimates of the probabilities of rare events in (high-dimensional) stochastic systems. The course will begin with general foundations of the theory of large deviations and will cover classical large deviations techniques. In the latter part of the course some recent developments, such as large deviations in the context of random graphs and matrices, and its application in statistical physics will be discussed.

Thangavelu S

References:
• Amir Dembo and Ofer Zeitouni, Large Deviations Techniques and Applications.
• Firas Rassoul-Agha and Timo Seppalainen, A Course on Large Deviations with an Introduction to Gibbs Measures.
• Marc Mezard and Andrea Montanari. Information, Physics, and Computation.
• Sourav Chatterjee. Large Deviations for Random Graphs.

Pre-requisites:
• This is a graduate level topics course in Probability theory. Graduate level measure theoretic probability will be useful, but not a requirement. The course will be accessible to advanced undergraduates who have had sufficient exposure to probability.
MA 399 (AUG) 2:0
Seminar on topics in Mathematics
Vamsi Pritham Pingali

MA 201 (JAN) 7:0
Project
Manjunath Krishnapur

MA 210 (JAN) 3:0
Logic, Types and Spaces
This course is an introduction to logic and foundations from both a modern point of view (based on type theory and its relations to topology) as well as in the traditional formulation based on first-order logic. Topics: Basic type theory: terms and types, function types, dependent types, inductive types. First order logic: First order languages, deduction and truth, Models, Godel’s completeness and compactness theorems. Godel’s incompleteness theorem Homotopy Type Theory: propositions as types, the identity type family, topological view of the identity type, foundations of homotopy type theory. Most of the material will be developed using the dependently typed language/proof assistant Agda. Connections with programming in functional languages will be explored.
Siddhartha Gadgil

Pre-requisites:
• No prior knowledge of logic is assumed. Some background in algebra and topology will be assumed. It will be useful to have some familiarity with programming.

MA 213 (JAN) 3:1
Algebra II
Soumya Das

Pre-requisites:
• MA 212
• Atiyah M. and MacDonald. R. Introduction to Commutative Algebra. Addison-Wesley(or any reprint).
MA 222 (JAN) 3:1

Analysis II


References:

Pre-requisites:
- MA 221

MA 224 (JAN) 3:1

Complex Analysis


Thangavelu S

Pre-requisites:
- MA 221

MA 229 (JAN) 3:0

Calculus on manifolds


Subhojoy Gupta

Pre-requisites:
- MA 221
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, Gronwall’s inequality, Dependence on initial conditions and associated flows. Linear system: The fundamental matrix, stability of equilibrium points, Phase-plane analysis, Sturm-Liouville theory. Nonlinear system and their stability: Lyapunov’s method, Non-linear Perturbation of linear systems, Periodic solutions and Poincare-Bendixson theorem

Thirupathi Gudi

References:

MA 278 (JAN) 3:0

Introduction to Dynamical Systems Theory


Janaki B

MA 311 (JAN) 3:0

Algebraic Geometry II


Abhishek Banerjee

References:

MA 316 (JAN) 3:0

Introduction to Homological Algebra

Polynomial ring, Projective modules, injective modules, flat modules, additive category, abelian category, exact functor, adjoint functors, (co)limits, category of complexes, snake lemma, derived functor, resolutions, Tor and Ext, dimension, local cohomology, group (co)homology, sheaf cohomology, Cech cohomology, Grothendieck spectral sequence, Leray spectral sequence.
Safdar Quddus

References:
- Cartan and Eilenberg, Homological Algebra
- Weibel, Introduction to Homological Algebra
- Rotman, Introduction to Homological Algebra

MA 319 (JAN) 3:0
Algebraic Combinatorics
The algebra of symmetric functions, Schur functions, RSK algorithm, Murnaghan- Nakayama Rule, Hillman-Grassl correspondence, Knuth equivalence, jeu de taquim, promotion and evacuation, Littlewood-Richardson rules. No prior knowledge of combinatorics is expected, but a familiarity with linear algebra and finite groups will be assumed.

Arvind Ayyer

References:
- Stanley R. Lecture notes on Topics in Algebraic Combinatorics.

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-requisites:

MA 327 (JAN) 3:0
Topics in analysis
Several important results in Analysis will be stated and proved, with emphasis on the techniques. Some of the topics that will be covered are: Isoperimetric inequality. Weyl’s equidistribution theorems. Uncertainty principles in harmonic analysis. Bieberbach’s conjecture for univalent functions. Maximal functions and their applications. Matching theorem and its applications. Trigonometric series and Brownian motion. Discrete analysis (Laplacian on graphs). Orthogonal polynomials. Asymptotics of integrals.

Manjunath Krishnapur

Pre-requisites:
- MA 223
- MA 224
MA 332 (JAN) 3:0
Algebraic Topology
Arun Maiti

Pre-requisites:
• MA 232
• Rotman, J, An Introduction to Algebraic Topology, Graduate Texts in Mathematics, 119, Springer-Verlag, 198
• Munkres, I. R., Elements of Algebraic Topology, Addison-Wesley, 1984
• Shastri, A. R., Basic Algebraic Topology, CRC Press, 2014

MA 338 (JAN) 3:0
Differentiable manifolds and Lie groups

Differentiable manifolds, differentiable maps, regular values and Sard’s theorem, submersions and immersions, tangent and cotangent bundles as examples of vector bundles, vector fields and flows, exponential map, Frobenius theorem, Lie groups and Lie algebras, exponential map, tensors and differential forms, exterior algebra, Lie derivative, Orientable manifolds, integration on manifolds and Stokes Theorem. Covariant differentiation, Riemannian metrics, Levi-Civita connection, Curvature and parallel transport, spaces of constant curvature.

Harish Seshadri

Pre-requisites:
• MA 219, MA 231
• Spivak M., A comprehensive introduction to differential geometry (Vol. 1) (3rd Ed.), Publish or Perish, Inc., Houston, Texas, 2005

MA 343 (JAN) 3:0
Complex analytic techniques in Operator Theory

Ando dilation of a commuting pair of contractions, Distinguished varieties of the bidisc, Description of all distinguished varieties, Construction of a distinguished variety corresponding to a pair of commuting matrices, Sharpening of Ando’s inequality, Extending the sharpened Ando inequality to operators with finite dimensional defect spaces, The extension property, Holomorphic retracts.

Bhattacharyya T

Pre-requisites:
• MA 223

MA 362 (JAN) 3:0
Stochastic Processes

First Construction of Brownian Motion, convergence in $C [ 0, 8 ]$, $D [ 0, 8 ]$, Donsker’s invariance principle, Properties of the Brownian motion, continuous-time martingales, optional sampling theorem,

Srikanth Krishnan Iyer

Pre-requisites:
- MA 361
- P. Billingsley, Convergence of probability measures
- Karatzas and Shreve, Brownian motion and stochastic calculus
- Revuz and Yor, Continuous martingales and Brownian motion
- A. Oksendal, Introduction to stochastic differential equations

MA 366 (JAN) 3:0

Stochastic Finance II


Mrinal Kanti Ghosh

Pre-requisites:

MA 384 (JAN) 3:0

Mathematical Physics

The purpose of this course will be to understand (to an extent) and appreciate the symbiotic relationship that exists between mathematics and physics. Topics to be covered can vary but those in this edition include: a brisk introduction to basic notions of differential geometry (manifolds, vector fields, metrics, geodesics, curvature, Lie groups and such), classical mechanics (Hamiltonian and Lagrangian formulations, n-body problems with special emphasis on the n=3 case) and time permitting, an introduction to integrable systems.

Kaushal Verma

References:
- Abraham and Marsden, Foundations of Mechanics ,AMS Chelsea
- V. I. Arnold, Mathematical Methods of Classical Mechanics, Springer, Graduate texts in mathematics 60
- H. Goldstein, Classical Mechanics ,Addison-Wesley.
- Hitchin, Segal and Ward, Integrable systems ,Oxford Univ Press

MA 385 (JAN) 3:0

Classical groups

General and special linear groups, bilinear forms, Symplectic groups, symmetric forms, quadratic forms, Orthogonal geometry, orthogonal groups, Clifford algebras, Hermitian forms, Unitary spaces, Unitary groups.

Pooja Singla
Pre-requisites:
• MA 212
• MA 219

MA 393 (JAN) 3:0
Topics in random discrete structures
Real trees, the Brownian continuum random tree, phase transition in random graphs, scaling limits of discrete combinatorial structures, random maps, the Brownian map and its geometry

Sanchayan Sen

Pre-requisites:
• MA 361
• Jean-François Le Gall, Random trees and applications , Probability Surveys (2005)
• Grégory Miermont, Aspects of random maps , Saint-Flour lecture notes (2014)

MA 399 (JAN) 2:0
Seminar in Topics in Mathematics
Kaushal Verma

MA 213 (MAY) 3:1
Algebra II

Soumya Das

Pre-requisites:
• MA 212
• Atiyah M. and MacDonald. R. Introduction to Commutative Algebra .Addison-Wesley(or any reprint).

MA 222 (MAY) 3:1
Analysis II
Pre-requisites:

- MA 221
Dept of Physics

Integrated Ph D Programme
Physical Sciences

Departmental Core Courses

PH 201 3:0 Classical Mechanics
PH 202 3:0 Statistical Mechanics
PH 203 3:0 Quantum Mechanics I
PH 204 3:0 Quantum Mechanics II
PH 205 3:0 Mathematical Methods of Physics
PH 206 3:0 Electromagnetic Theory
PH 207 1:2 Analog Digital and Microprocessor Electronics
PH 208 3:0 Condensed Matter Physics-I
PH 209 2:1 Analog and Digital Electronics Lab
PH 211 0:3 General Physics Laboratory
PH 212 0:3 Experiments in Condensed Matter Physics
PH 213 0:4 Advanced Experiments in Condensed Matter Physics
HE 215 3:0 Nuclear and Particle Physics
PH 217 3:0 Fundamentals of Astrophysics
PH 231 0:1 Workshop practice
PH 300 1:0 Seminar Course

Project:
PH 250A 0:6 Project
PH 250B 0:6 Project

Elective Courses:
HE 316 3:0 Advanced Mathematical Methods
PH 320 3:0 Condensed Matter Physics II
PH 325 3:0 Advanced Statistical Physics
PH 330 0:3 Advanced Independent Project
PH 340 4:0 Quantum Statistical Field Theory
PH 347 2:0 Bioinformatics
PH 350 3:0 Physics of Soft Condensed Matter
PH 351 3:0 Crystal Growth, Thin Films and Characterization
PH 352 3:0 Semiconductor Physics and Technology
PH 359 3:0 Physics at the Nanoscale
PH 362 3:0 Matter at Low Temperatures
HE 392 3:0 Standard Model of Particle Physics
HE 395 3:0 Quantum Mechanics III
HE 396 3:0 Gauge Field Theories
**PH 201 (AUG) 3:0**  
**Classical Mechanics**  

**Rajeev Kumar Jain**

**References:**
- Goldstein, H., Classical Mechanics, Second Edn, Narosa

**PH 203 (AUG) 3:0**  
**Quantum Mechanics-I**  

**Manish Jain**

**Pre-requisites:**
- Cohen-Tannoudji, C., Diu, B., and Laloe

**PH 205 (AUG) 3:0**  
**Math Methods of Physics**  

**Sumilan Banerjee**

**Pre-requisites:**
- Mathews, J., and Walker, R.L., Mathematical Methods of Physics

**PH 209 (AUG) 2:1**  
**Electronics II**  
Introduction to microprocessors, Intel 80x86 architecture and instruction set. Assembly and C level programming, memory and IO interfacing. Mini projects using integrated circuits, data acquisition systems. PC add-on boards. Introduction to virtual instrumentation.
References:


PH 211 (AUG) 0:3

General Physics Laboratory

Identification of NaCl monocrystals using x-ray diffraction, Gamma ray absorption with MCA (calibration and attenuation coefficient), Nuclear Magnetic Resonance (find the magnetogyric ratio of Hydrogen and Fluorine), Velocity of sound in liquids (Raman-Nath experiment), Normal modes in 3D Acoustic Resonant Chamber, Solar Cell (I-V characterization), UV-VIS spectroscopy (Band gap of semiconductor and insulator, thickness measurement), Elastic Plastic deformation of metal wire, X-ray Fluorescence with MCA, Rutherford Scattering

Victor Suvisesha Muthu D, Vasant Natarajan, Srimanta Middey

Pre-requisites:
- practical course, practical course, practicals

PH 213 (AUG) 0:4

Advanced Experiments in Condensed matter physics

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

Ganesan R, Anil Kumar P S

Pre-requisites:
- practical course, practical course, practical course

PH 215 (AUG) 3:0

Nuclear and Particle Physics


Sudhir Kumar Vempati

Pre-requisites:

PH 217 (AUG) 3:0

Fundamentals of Astrophysics

Prateek Sharma

Pre-requisites:
- Choudhuri, A.R., Astrophysics for Physicists, Shu, F.

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

Vasant Natarajan

Pre-requisites:
- practical course, practical course, practical course

PH 300 (AUG) 0:1
Seminar Course
The course aims to help the fresh research student in seminar preparation, presentation and participation. The seminars will be given by the course registrants, after proper guidance by the instructors.

Arindam Ghosh, Anindya Das

Pre-requisites:
- Seminar course, Seminar Course, Seminar Course, Regular PhD students in physics

PH 320 (AUG) 3:0
Condensed Matter Physics II

Subroto Mukerjee

Pre-requisites:
- Ashcroft, N.W., and Mermin, N.D., Solid State Physics

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.

**Rahul Pandit**

**Pre-requisites:**
- Chaikin, P.M., and Lubensky, T.C., *Principles of Condensed Matter Physics*

**PH 330 (AUG) 0:3**

**Advanced Independent Project**

Open to research students only

**Pre-requisites:**
- Project Course, Project Course, Project Course

**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., thickness measurements and characterization such as RHEED, LEED thin-film XRD, etc.

**Suja Elizabeth, Anil Kumar P S**

**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

**Sriram Ramaswamy**

**Pre-requisites:**
- Mechanics and Statistical physics at 1st-year graduate student level

**PH 362 (AUG) 2:0**

**Radiative Processes in Astrophysics**


**Prateek Sharma**
**PH 363 (AUG) 2:0**  
**Introduction to Fluid Mechanics and Plasma Physics**


**Rajeev Kumar Jain**

**Pre-requisites:**

**PH 391 (AUG) 3:0**  
**Quantum Mechanics III**

**Apoorva Patel**

**PH 392 (AUG) 3:0**  
**Standard model particle physics**

**Aninda Sinha**

**PH 395 (AUG) 3:0**  
**Quantum Field Theory I**


**Prasad Satish Hegde**

**Pre-requisites:**
- PHY 203 Quantum Mechanics I
- PHY 204 Quantum Mechanics II

**Co-requisites:**
- PHY 201 Classical Mechanics

**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.

Chethan Krishnan

References:

PH 206 (JAN) 3:0
Electromagnetic Theory

Animesh Kuley

References:

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.

Rajan K

References:

PH 208 (JAN) 3:0
Condensed Matter Physics-I
Drude model, Sommerfeld model, crystal lattices, reciprocal lattice, X-ray diffraction, Brillouin zones and Fermi surfaces, Bloch’s theorem, nearly free electrons, tight binding model, selected band structures, semi-classical dynamics of electrons, measuring Fermi surfaces, cohesive energy, classical harmonic crystal, quantum harmonic crystal, phonons in metals, semiconductors, diamagnetism and paramagnetism, magnetic interactions.

Aveek Bid, Srimanta Middey
References:
• Ashcroft,N.W.,and Mermin,N.D.,Solid State Physics

PH 250 (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 (PH 250B).

Pre-requisites:
• Project Course,Project Course,Project Course

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

Arindam Ghosh

PH 316 (JAN) 3:0
Advanced Mathematical Methods

Sachindeo Vaidya

References:

PH 322 (JAN) 3:0
Molecular Simulation
Introduction to molecular dynamics, various schemes for integration, inter- and intra-molecular forces, introduction to various force fields, methods for partial atomic charges, various ensembles (NVE, NVT, NPT, NPH), hard sphere simulations, water simulations, computing long-range interactions. Various schemes for minimization: conjugate gradient, steepest descents. Monte Carlo simulations, the Ising model, various sampling methods, particle-based MC simulations, biased Monte Carlo. Density functional theory, free energy calculations, umbrella sampling, smart Monte Carlo, liquid crystal simulations, introduction to biomolecule simulations

Prabal Kumar Maiti

Pre-requisites:
• Basic courses in statistical physics, quantum mechanics,Basic courses in statistical physics, quantum mechanics,Basic courses in statistical physics, quantum mechanics
PH 340 (JAN) 3:0
Quantum Statistical Field Theory
Subroto Mukerjee

PH 352 (JAN) 3:0
Semiconductor Physics
Semiconductor fundamentals: band structure, electron and hole statistics, intrinsic and extrinsic semiconductors, energy band diagrams, drift-diffusion transport, generation - recombination, optical absorption and emission. Basic semiconductor devices: on junctions, bipolar transistors, MOS capacitors, field-effect devices, optical detectors and emitters. Semiconductor technology: fundamentals of semiconductor processing techniques; introduction to planar technology for integrated circuits
Ramesh Chandra Mallik

References:
• Seeger, K., Semiconductor Physics, Springer-Verlag, 1990.

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

References:
• Forman Acton, Real computing made real: Preventing Errors in Scientific and Engineering Calculations, Dover Publications.
• Lloyd N. Trefethen and David Bau, Numerical Linear Algebra, SIAM.

PH 359 (JAN) 3:0
Physics at the Nanoscale
Introduction to different nanosystems and their realization, electronic properties of quantum confined systems: quantum wells, wires, nanotubes and dots. Optical properties of nanosystems: excitons and plasmons, photoluminescence, absorption spectra, vibrational and thermal properties of nanosystems, Zone folding. Raman characterization
Arindam Ghosh, Ambarish Ghosh

References:
• Delerue,C and Lannoo,M.,Nanostructures: Theory and Modelling,Springer

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-requisites:
- "Topological insulators", Shun-Qing Shen, Springer
- "Topological insulators and topological superconductors" B. Andrei Bernevig, and T. L. Hughes, Princeton University Press
- "Topological insulators- The physics of spin helicity in quantum transport" G. Tkachov, Pan Stanford publishing
- "Topological insulators" Marcel Franz, and L. Molenkamp, Elsevier
- "Colloquium: Topological insulators", M. Z. Hasan, C. L. Kane, Rev. Mod. Phys. 82, 3045 (2010)

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.

Nirupam Roy

References:
- Mihalas, D. and Binney, J.: Galactic Astronomy
- Binney, J. and Tremaine, S.: Galactic Dynamics
- Spitzer, L.: Physical Process in the Interstellar Medium

PH 366 (JAN) 3:0
Physics of Advanced Optical Materials

Syllabus: Introduction to novel optical materials; Quantum dots, plasmonic nanoparticles, two dimensional materials, metamaterials, photonic crystals; Fundamental excitations is optical materials and their interactions; weak (Purcell) and strong coupling (Rabi) – classical and quantum treatments; wave optics; Fourier optics and microscopy; Maxwell's electromagnetic waves; resonators; quantum theory of photons; light-matter interaction; optical and optofluidic forces in colloidal materials; Advanced experimental techniques to probe optical materials – steady state and time resolved measurements; super-resolution techniques; optical tweezers; anti-bunching and photon correlations.

Jaydeep Kumar Basu, Ambarish Ghosh

References:

Pre-requisites:
- QM-I and QM-II; Solid State Physics; Introduction to Photonics; Electromagnetic theory; or equivalent courses.

PH 371 (JAN) 3:0
General Relativity & Cosmology

universe. The microwave background. Formation of structures.

Banibrata Mukhopadhyay

References:

PH 377 (JAN) 2:0
Astronomical Techniques (Seminar Course)

Radio: coordinate system, detection principles, resolution and sensitivity, interferometry and aperturesynthesis. IR/Optical/UV: CCD fundamentals, imaging systems, point-spread-function, sensitivity, photometry and spectroscopy, speckle techniques, adaptive optics. X-ray/Gamma-ray astrophysics: detection principles, detectors and imaging systems, resolution and sensitivity, detector response, data analysis methods for spectroscopic and timing studies. Coordinated laboratory / data analysis exercises in each of the three areas.

Nirupam Roy

References:

PH 396 (JAN) 3:0
Quantum Field Theory 2


Ananthanarayan B

Pre-requisites:

PH 398 (JAN) 3:0
General Relativity


Justin Raj David
Electromagnetic Theory


Animesh Kuley

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

Arindam Ghosh

References:

**Centre for High Energy Physics**

**HE 215 (AUG) 3:0**

**Nuclear and Particle Physics**


**Sudhir Kumar Vempati**

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

**Pre-requisites:**
- PHY 204 Quantum Mechanics II

**HE 386 (AUG) 3:0**

**Experimental High Energy Physics**


**Jyothsna Rani Komaragiri**

**References:**

**Co-requisites:**
- HE 215 Nuclear and Particle Physics

**HE 389 (AUG) 3:0**

**AdS/CFT -or- Quantum Gravity in Anti-de Sitter Space**

compelling. The spectrum of AdS/CFT. String theory origins and Maldacena's original version of the conjecture, AdS3/CFT2, Bulk locality and reconstruction.

Chethan Krishnan

References:

Pre-requisites:
• HE 395 Quantum Field Theory I

HE 316 (JAN) 3:0
Advanced Mathematical Methods in Physics


Sachindeo Vaidya

References:
• Georgi H., Lie Algebras in Particle Physics (Second edition), Perseus Books, 1999
• Hamermesh M., Group Theory and its Applications to Physical Problems, Addison-Wesley, 1962

HE 322 (JAN) 3:0
QCD and Collider Physics


Biplob Bhattacharjee

References:
• Ellis R., Stirling W. and Webber B., QCD and Collider Physics, (Cambridge Monographs on Particle Physics, Nuclear Physics and Cosmology) Cambridge University Press, 1996

Pre-requisites:
• HE 395 Quantum Field Theory I

HE 384 (JAN) 3:0
Quantum Computation


Apoorva Patel

References:
- Preskill J., Lecture Notes for the Course on Quantum Computation, http://www.theory.caltech.edu/people/preskill/ph229

HE 396 (JAN) 3:0
Quantum Field Theory II


Ananthanarayan B

References:
- Schwartz M.D., Quantum field theory and the standard model, Cambridge University Press, 2014.
- Bjorken J.D. and Drell S., Relativistic Quantum Mechanics, McGraw-Hill, 1965

Pre-requisites:
- HE 395 Quantum Field Theory I

HE 397 (JAN) 3:0
The Standard Model of Particle Physics


Aninda Sinha

References:
- Halzen F. and Martin A.D., Quarks and Leptons: An Introductory Course in Modern Particle Physics, John Wiley & Sons, 1984
- Georgi H.,Weak Interactions and Modern Particle Theory,Benjamin/Cummings,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, 1995

Pre-requisites:
- HE 395 Quantum Field Theory I
HE 398 (JAN) 3:0

General Relativity


Justin Raj David

References:

• Wald R.M., General Relativity, Overseas Press, 2006
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
- EP  Dissertation Project

All the departments in the Division provide facilities for research work leading to the Ph.D and 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)

Prof. Y Narahari
Chair,
Division of EECS
Department of Computer Science and Automation

M.Tech Program

M.Tech students are expected to take a minimum of two courses from each of the three pools - Pool A, Pool B, and Pool C, during the course of their program.

Aug-Dec 2019

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## January – April 2020

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<td><strong>Pool A</strong></td>
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<td>E0 228</td>
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<td>Combinatorics</td>
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<td>E0 244</td>
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<td>Computational Geometry and Topology</td>
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<td>E0 248</td>
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<td>Theoretical Foundations of Cryptography</td>
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<td>E0 249</td>
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<td>Approximation Algorithms</td>
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<td><strong>Pool B</strong></td>
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<td>E0 210</td>
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<td>Dynamic Program Analysis: Algorithms and Tools</td>
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<td>E0 253</td>
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<td>Operating Systems</td>
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<td>Compiler Design</td>
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<td>Database Management Systems</td>
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<td>Formal Methods in Software Engineering</td>
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<td>E0 238</td>
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<td>E0 268</td>
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<td>E1 254</td>
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<td>Computational Cognitive Neuroscience</td>
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<td>Blockchain and Its Applications</td>
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<td>E0 338</td>
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<td>Topics in Security and Privacy</td>
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<td>Program Synthesis meets Machine Learning</td>
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<td>E0 399</td>
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<td>Research in Computer Science</td>
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<td>E1 313</td>
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<td>Topics in Pattern Recognition</td>
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</table>
Dynamic Program Analysis: Algorithms and Tools

Motivation and objectives of the course: The design and implementation of scalable, reliable and secure software systems is critical for many modern applications. Numerous program analyses are designed to aid the programmer in building such systems and significant advances have been made in recent years. The objective of the course includes introduction of the practical issues associated with programming for modern applications, the algorithms underlying these analyses, and applicability of these approaches to large systems. There will be special emphasis on practical issues found in modern software. The course project will be geared towards building the programming skills required for implementing large software systems. Syllabus: The course will introduce the students to the following topics -- bytecode instrumentation; profiling -- BL profiling, profiling in the presence of loops, preferential path profiling, memory profiling; software bloat; lock-free data structures; memoization; map-reduce programming model; approximate computing; multithreading; fuzzing techniques; record and replay; memory models; data races -- lockset algorithm, happens-before relation, causally-precedes relation; atomicity violations; deadlocks; linearizability; symbolic execution; concolic testing; directed program synthesis; constraint solving; deterministic/stable multithreaded systems; floating-point problems; security -- sql-injection, cross-site scripting, return-oriented programming, obfuscation; malware detection. References: Course material available from the webpage; research papers

Gopinath K

Pre-requisites:
- Basic knowledge of programming in C/C++/Java.

Design and Analysis of Algorithms


Anand Louis, Arindam Khan

Linear Algebra and Probability


Narasimha Murty M, Shalabh Bhatnagar

References:
- Hoffman and Kunze
E0 227 (AUG) 3:1
Program Analysis and Verification


Deepak DSouza, Raghavan K V

Pre-requisites:
• Exposure to programming, and the basics of mathematical logic and discrete structures.

E0 229 (AUG) 3:1
Foundations of Data Science

High Dimensional Geometry, SVD and applications, Random Graphs, Markov Chains, Algorithms in Machine Learning, Clustering, Massive data and Sampling on the fly

Siddharth Barman

References:
• Foundations of Data Science by Blum, Hopcroft, and Kannan

Pre-requisites:
• Basic Linear Algebra, Probability, and Algorithms

E0 230 (AUG) 3:1
Computational Methods of Optimization


Chiranjib Bhattacharyya

References:

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

Sanjit Chatterjee, Arpita Patra

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.

Arkaprava Basu

Pre-requisites:
• Hennessy
• J.L.
• and Patterson
• D.A.: Computer Architecture
• A quantitative Approach Morgan Kaufmann.,Stone,H.S.: High-Performance Computer Architecture, Addison-Wesley., Current literature

E0 251 (AUG) 3:1
Data Structures and Algorithms

Srikant Y N

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

E0 254 (AUG) 3:1
Network and Distributed Systems Security
Security Goals and Violations; Security Requirements; Security Services; Discrete Logs, Encryption/Decryption Functions, Hash Functions, MAC Functions; Requirements and Algorithmic Implementation of One-Way Functions; OS Security Violations and Techniques to Prevent Them; Access Control Models; Secure Programming Techniques; Authenticated Diffie-Hellman Key Establishment Protocols; Group Key Establishment Protocols; Block Ciphers and Stream Ciphers; Modes of Encryption; Digital Signatures; Authentication Protocols; Nonce and Timestamps; PKI and X.509 Authentication Service; BAN logic; Kerberos; E-mail Security; IP Security; Secure Socket Layer and Transport Layer Security; Secure Electronic Transactions; Intrusion Detection; Malicious Software

Pre-requisites:
- Knowledge of Java is desirable, but not necessary.

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-requisites:
- None, but standard undergraduate-level exposure to OS, computer architecture and compilers courses will be assumed.

E0 267 (AUG) 3:1

Soft Computing


Susheela Devi V
**E0 271 (AUG) 3:1**  
**Graphics and Visualization**

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

**Vijay Natarajan**

**References:**

**Pre-requisites:**
- Undergraduate courses in data structures, algorithms, programming, and linear algebra.

**E0 311 (AUG) 3:1**  
**Topics in Combinatorics**

Tools from combinatorics is used in several areas of computer science. This course aims to teach some advanced techniques and topics in combinatorics. In particular, we would like to cover probabilistic method which is not covered in the introductory course 'graph theory and combinatorics'. Moreover the course would aim to cover to some extent the linear algebraic methods used in combinatorics. We will also discuss some topics from extremal combinatorics. Linear Algebraic methods: Basic techniques, polynomial space method, higher incidence matrices, applications to combinatorial and geometric problems. Probabilistic Methods: Basic techniques, entropy based method, martingales, random graphs. Extremal Combinatorics: Sun flowers, intersecting families, Chains and antichains, Ramsey theory.

**Sunil Chandran L**

**References:**
- L. Babai and P. Frankl: Linear algebra methods in combinatorics with applications to Geometry and Computer Science, Unpublished manuscript.
- N. Alon and J. Spenser: Probabilistic Method, Wiley Inter-science publication.
- Stasys Jukna: Extremal Combinatorics with applications in computer science, Springer.

**E0 312 (AUG) 3:1**  
**Foundations of Secure Computation**


**Arpita Patra**

**Pre-requisites:**
- Mathematical maturity.,Basic level crypto course.
E0 334 (AUG) 3:1
Deep Learning for Natural Language Processing


Recent Literature.

Shirish Krishnaji Shevade

Pre-requisites:
• A course on Machine Learning or equivalent

E0 337 (AUG) 3:1
Topics in Advanced Cryptography

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

Bhavana Kanukurthi

Pre-requisites:
• A course in Cryptography and mathematical maturity.

E0 358 (AUG) 3:1
Advanced Techniques in Compilation and Programming for Parallel Architectures

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

Uday Kumar Reddy B

References:
• 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.

Pre-requisites:
• Knowledge of "E0 255 Compiler Design" course content (especially on parallelization) will be very useful, but not absolutely necessary.
• Knowledge of microprocessor architecture and some basic understanding of parallel programming models.
E0 399 (AUG) 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.

Srikant Y N, Shirish Krishnaji Shevade, Deepak DSouza

References:
• Recent literature
Pre-requisites:
• Prior consent of instructor(s)

E0 210 (JAN) 3:1
Dynamic Program Analysis: Algorithms and Tools

Motivation and objectives of the course: The design and implementation of scalable, reliable and secure software systems is critical for many modern applications. Numerous program analyses are designed to aid the programmer in building such systems and significant advances have been made in recent years. The objective of the course includes introduction of the practical issues associated with programming for modern applications, the algorithms underlying these analyses, and applicability of these approaches to large systems. There will be special emphasis on practical issues found in modern software. The course project will be geared towards building the programming skills required for implementing large software systems. Syllabus: The course will introduce the students to the following topics -- bytecode instrumentation; profiling -- BL profiling, profiling in the presence of loops, preferential path profiling, memory profiling; software bloat; lock-free data structures; memoization; map-reduce programming model; approximate computing; multithreading; fuzzing techniques; record and replay; memory models; data races -- lockset algorithm, happens-before relation, causally-precedes relation; atomicity violations; deadlocks; linearizability; symbolic execution; concolic testing; directed program synthesis; constraint solving; deterministic/stable multithreaded systems; floating-point problems; security -- sql-injection, cross-site scripting, return-oriented programming, obfuscation; malware detection.

Gopinath K

References:
• Course material available from the webpage; research papers
Pre-requisites:
• Basic knowledge of programming in C/C++/Java.

E0 228 (JAN) 3:1
Combinatorics

Basic combinatorial numbers, selection with repetition, pigeon hole principle, Inclusion-Exclusion Principle, Double counting; Recurrence Relations, Generating functions; Special combinatorial numbers: Sterling numbers of the first and second kind, Catalan numbers, Partition numbers; Introduction to Ramsey theory; Combinatorial designs, Latin squares; Introduction to Probabilistic methods, Introduction to Linear algebra methods.

Sunil Chandran L
References:
- Noga Alon, Joel H. Spencer, P. Erdos, "The Probabilistic methods", Wiley Interscience Publication
- Laszlo Babai and Peter Frankl, "Linear Algebra Methods in Combinatorics, with Applications to Geometry and Computer Science" (Unpublished Manuscript, 1992)

Pre-requisites:
- None. (A very basic familiarity with probability theory and linear algebra is preferred, but not a must. The required concepts will be introduced quickly in the course.)

E0 238 (JAN) 3:1
Intelligent Agents


Susheela Devi V

E0 244 (JAN) 3:1
Computational Geometry and Topology

Voronoi diagram, Delaunay triangulation, Geometric Data Structures — Interval tree, Range tree, Segment tree. Complexes — simplicial complex, Rips complex, alpha complex, homology, Betti numbers, persistence homology, Morse functions, Reeb graph, approximation and fixed parameter algorithms for geometric problems - hitting set and set cover, epsilon nets, epsilon approximations, geometric intersection graphs, geometric discrepancy, clustering.

Vijay Natarajan, Sathish Govindarajan

References:

Pre-requisites:
- E0225 : Design and Analysis of Algorithms

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
E0 249 (JAN) 3:1

Approximation Algorithms

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

Anand Louis, Arindam Khan

Pre-requisites:
• E0225: Design and Analysis of Algorithms.

E0 253 (JAN) 3:1

Operating Systems


Vinod Ganapathy, Arkaprava Basu

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 of language design and architecture evolution on compilers. References: Aho, A.V., Ravi Sethi and J.D. Ullman: Compilers - Principles, Techniques and Tools, Addison Wesley, 1988. S. Muchnick: Advanced Compiler Design and Implementation, Morgan Kauffman, 1998 Selected Papers.

Srikant Y N, Govindarajan R
E0 261 (JAN) 3:1
Database Management Systems
Design of Database Kernels, Query Optimization, Query Processing, Data Access Methods, Transaction Management, Distributed Databases, Data Mining, Data Warehousing, Main-Memory Databases, Columnar Databases, NoSQL systems.

Jayant R Haritsa

References:
- Readings in Database Systems M. Stonebraker and J. Hellerstein, Morgan Kaufmann.
- Recent Conference and Journal papers.

Pre-requisites:
- Data Structures, C or C++, Undergraduate course in DBMS

E0 264 (JAN) 3:1
Distributed Computing Systems

Ramesh Chandra Hansdah

Pre-requisites:
- NDSS(E0 254) or equivalent course

E0 268 (JAN) 3:1
Practical Data Science
Shirish Krishnaji Shevade

Pre-requisites:
• Linear Algebra, Probability and Statistics, Some programming experience in any language.

E0 270 (JAN) 3:1
Machine Learning


Chiranjib Bhattacharyya, Ambedkar Dukkipati

References:
• Goodfellow, Bengio, Courville, Deep Learning, MIT Press, 2017

Pre-requisites:
• Probability and Statistics (or equivalent course elsewhere). Some background in linear algebra and optimization will be helpful.

E0 272 (JAN) 3:1
Formal Methods in Software Engineering

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

Deepak DSouza, Raghavan K V

References:
• Logic in Computer Science: Modelling and Reasoning about Systems, by Michael Huth and Mark Ryan.
• Software Abstractions: Logic, Language, and Analysis, by Daniel Jackson.
• Model Checking, by Edmund M. Clarke, Oma Grumberg, and Doron Peled.
• Research papers.

Pre-requisites:
• Exposure to programming, and the basics of mathematical logic and discrete structures.

E0 304 (JAN) 3:1
Computational Cognitive Neuroscience

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

Sridharan Devarajan

Pre-requisites:
- Familiarity with machine learning, dimensionality reduction, and linear algebra at the advanced undergraduate/early graduate level. Knowledge of coding (e.g. C/Matlab/Python) is essential. Some background in neuroscience is preferred, but not essential (background readings will be provided).

E0 305 (JAN) 3:1
Blockchain and its Applications

Motivation and objectives of the course: Blockchains and its applications in cryptography that include cryptocurrencies are emerging technologies. This course will cover blockchains and their applications to cryptocurrencies such as Bitcoin, distributed consensus and multiparty computation (MPC), smart contracts and beyond. Syllabus: a) Introduction to Blockchain and its cryptographic building blocks; (b) Blockchain Analysis (c) Introduction to Cryptocurrencies, Bitcoin and its alternative cryptocurrencies (d) Applications of Blockchains beyond cryptocurrencies (such as in consensus, multi-party computation (MPC), smart contracts); (e) Alternatives of Blockchains. References: Bitcoin and Cryptocurrency Technologies: A Comprehensive Introduction by Arvind Narayanan, Joseph Bonneau, Edward W. Felten, Andrew Miller, Steven Goldfeder and Jeremy Clark. Princeton University Press, 2016. Mastering Bitcoins: Unlocking Digital Cryptocurrencies by Andreas Antonopoulos. O'Reilly Media, Inc, 2013. Recent research papers and reports.

Arpita Patra

Pre-requisites:
- Mathematical maturity will be assumed.

E0 307 (JAN) 3:1
Program Synthesis meets Machine Learning

This course will have two parts: Part 1: In this part, we will cover the theory and fundamentals of program synthesis, including the recent formulations to restrict synthesis using templates, and reformulate synthesis as a search problem. We will also cover black-box formulations of synthesis, starting with the classic Angluin’s algorithm [5] to its modern variants [6]. We will teach this part in a structured manner through planned lectures. Part 2: In this part, we will read and discuss recent papers exploring the combination of machine learning and program synthesis. Specific topics include: - Using ML to Rank Programs and Prune Search Space for Program Synthesis [7, 8] - Combining ML and synthesis [9] - Neural program induction [10, 11] - Automatic differentiation [12, 13] Motivation and objectives of the course: Program synthesis has its roots in formal methods and programming languages. The goal of program synthesis is to automatically generate a program (from a space of possible programs) which satisfies a specification written in logic. The problem has its roots in a paper by Church in 1957, and the initial breakthroughs were made by Buchi and Landweber (1969) and M O Rabin (1972) , who showed that the synthesis problem is decidable for specifications written in certain logics. However, the complexity of the algorithms was too high (Non-Elementary to EXPTIME) to be useful in practice. Recent formulations have made synthesis more practical . In his PhD thesis, Solar-Lezama formulated synthesis as “sketching” [2] , a process where part of the program is given by the user as a template and the synthesizer merely fills in "holes" in the sketch using search. Another recent formulation, due to Sumit Gulwani uses input/output examples (rather than formulas) as specifications [3] , and uses clever search algorithms to generate appropriate programs. Sparked by these two works, there has been a resurgence or work in program synthesis in the past decade. There is an annual Sygus
Recently there is an interesting interplay developing between program synthesis and machine learning. Machine learning uses continuous optimization methods to learn models that minimize a specified loss function, whereas program synthesis uses discrete combinatorial search to learn programs that satisfy a specification. While program synthesis produces interpretable programs, which can be formally verified, machine learning deals with noise in the inputs more gracefully. There is a rich body of recent work in combining machine learning and program synthesis to get the benefits of both approaches.

Chiranjib Bhattacharyya, Deepak DSouza

References:
• Alonzo Church, Application of recursive arithmetic to the problem of circuit synthesis, Summaries of talks presented at the Summer Institute for Symbolic Logic Cornell University, 1957.
• Sumit Gulwani, Automating String Processing in Spreadsheets using Input-Output Examples. POPL 2011.
• Vandrager, F. Model Learning, CACM, Feb 2017.
• Sumit Gulwani, Prateek Jain, Programming by Examples: PL meets ML, Dependable Software Systems Engineering, Published by IOS Press, 2019.
• Alex Graves, Greg Wayne, Ivo Danihelka, Neural Turing Machines, 2014.
• Scott Reed, Nando de Freitas, Neural Programmer Interpreters, 2016.
• Pearlmutter & Siskind, Reverse mode AD in a functional framework, TOPLAS 2008.
• Elliott, The simple essence of automatic differentiation, ICFP 2018

Pre-requisites:
• We require students to have good knowledge in programming. We also require students to have taken an introductory course in Machine Learning (regression, classification, deep learning etc). We will not require prior exposure to program synthesis or formal methods. We will supply the necessary background in Part 1. Students will need to show initiative in reading papers for Part 2, and leading discussions in Part 2. Students will also need to do both theory and implementation for the project.

E0 338 (JAN) 3:1
Topics in Security and Privacy

Recent technological advances in diverse domains such as CPS/IoT, cloud storage and computation, quantum information processing as well as proliferation of tools for digital mass surveillance have thrown up many interesting research problems. This course will focus on some of the theoretical questions in Security and Privacy from a cryptographic perspective. We plan to cover a subset of the following topics:(A) Cryptographic Security in a Post-Quantum World,(B) Design and Analysis of Privacy Enhancing Tools,(C) Efficient, Secure and Verifiable Query Processing in Outsourced Database,(D) Cryptocurrency, Smart Contracts, Blockchain and Applications. References: Recent research papers in the relevant areas.

Sanjit Chatterjee

Pre-requisites:
• Good performance in E0 235 (Cryptography) and consent of the instructor.

E0 399 (JAN) 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.

Srikant Y N, Shirish Krishnaji Shevade, Deepak DSouza

References:
- Recent literature

Pre-requisites:
- Prior consent of instructor(s)

E1 254 (JAN) 3:1
Game Theory


Narahari Y, Siddharth Barman

E1 277 (JAN) 3:1
Reinforcement Learning


Shalabh Bhatnagar

E1 313 (JAN) 3:1
Topics in Pattern Recognition

Project

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.

Uday Kumar Reddy B, Vinod Ganapathy
OVERALL STRUCTURE

The programme requires 36 units of coursework and 28 units of project work with a Major and Minor Structure.

MAJOR AND MINOR STRUCTURE

MINORS

(a) A new feature of the programme is that it give the students the option to graduate with one of 4 "Minors":
   (i) Minor in Integrated Circuits & Systems,
   (ii) Minor in Photonics,
   (iii) Minor in Radio-Frequency Systems,
   (iv) Minor in Signal Processing

(b) The selection of a Minor is not however, mandatory.

(c) A student qualifies for a Minor if he/she takes at least 3 courses belonging to a basket of courses specific to each area.

(d) This basket of courses is further divided into two pools, Pool X and Pool Y and a student is required to take a total of 3 courses from Pool X and Pool Y combined and
   (i) at least two courses from Pool X in the case of a Minor in Integrated Circuits & Systems,
   (ii) at least one course from Pool X in the case of a Minor in either Photonics, Radio-Frequency Systems or Signal Processing.

(e) The selection of a minor takes place during the course of the programme by the student in consultation with his Faculty Advisor.

(f) It is understood that the default Major of all students enrolled in the programme is Communication & Networks.

(g) A student who does not opt for a Minor, can either choose to specialize further in the Major by taking 3 additional courses in the area of Communication & Networks or else choosing amongst the many electives available (in consultation with his/her Faculty Advisor).

SAMPLE COURSE-UNIT BREAKUP

Here is a sample breakup of course units for a student opting for one of the Minors and taking two courses with placement in mind.

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
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<tbody>
<tr>
<td>Core</td>
<td>4</td>
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<tr>
<td>Soft Core</td>
<td>3</td>
</tr>
<tr>
<td>Electives</td>
<td>2</td>
</tr>
<tr>
<td>Minor or Electives</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Course</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>4 courses</td>
<td>12</td>
</tr>
<tr>
<td>3 courses</td>
<td>9</td>
</tr>
<tr>
<td>2 courses</td>
<td>6</td>
</tr>
<tr>
<td>3 courses</td>
<td>9</td>
</tr>
<tr>
<td>36 units</td>
<td></td>
</tr>
</tbody>
</table>
THE CORE

The following courses are required of every student in the programme and hence constitute the Core

(a) E2 202 (AUG) 3:0 Random Processes
(b) E2 211 (AUG) 3:0 Digital Communication
(c) E2 221 (AUG) 3:0 Communication Networks
(d) E1 244 (JAN) 3:0 Detection and Estimation Theory

SOFTCORE

(a) Students are required to take a total of 3 courses from the two pools, Pool A and B below.
(b) At least 2 of these courses must be from Pool A.

<table>
<thead>
<tr>
<th>Pool A (in no particular order)</th>
</tr>
</thead>
<tbody>
<tr>
<td>E2 201 (AUG) 3:0 Information Theory</td>
</tr>
<tr>
<td>E2 203 (JAN) 3:0 Wireless Communication</td>
</tr>
<tr>
<td>E2 204 (JAN) 3:0 Stochastic Processes and Queueing Theory</td>
</tr>
<tr>
<td>E2 205 (AUG) 3:0 Error-Correcting Codes</td>
</tr>
<tr>
<td>E2 223 (AUG) 3:0 Communication Protocols</td>
</tr>
<tr>
<td>E2 241 (JAN) 3:0 Wireless Networks</td>
</tr>
<tr>
<td>E2 242 (JAN) 3:0 CDMA &amp; Multiuser Detection</td>
</tr>
<tr>
<td>E8 203 (AUG) 3:0 RF &amp; Optical Engineering</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pool B (in no particular order)</th>
</tr>
</thead>
<tbody>
<tr>
<td>E0 251 (AUG) 3:1 Data Structures &amp; Algorithms</td>
</tr>
<tr>
<td>E0 259 (AUG) 3:1 Data Analytics</td>
</tr>
<tr>
<td>E1 251 (AUG) 3:0 Linear and Nonlinear Optimization</td>
</tr>
<tr>
<td>E1 254 (AUG/JAN) 3:1 Game Theory</td>
</tr>
<tr>
<td>E2 212 (AUG) 3:0 Matrix Theory</td>
</tr>
<tr>
<td>E9 201 (AUG) 3:0 Digital Signal Processing</td>
</tr>
<tr>
<td>E9 211 (JAN) 3:0 Adaptive Signal Processing</td>
</tr>
</tbody>
</table>
REQUIREMENTS FOR EACH MINOR

A. Minor in Integrated Circuits and Systems (ICS)

Requirements:

• Any 3 of the courses listed below under Pools X & Y
• with at least two courses from Pool X will qualify a student for a "Minor in Integrated Circuits and Systems".

<table>
<thead>
<tr>
<th>Pool X</th>
<th>Pool Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>NE 205 (AUG) 3:0</td>
<td>E3 237 (JAN) 3:0 Integrated Circuits for Wireless Communication</td>
</tr>
<tr>
<td>E3 238 (AUG) 2:1</td>
<td>E3 239 (JAN) 2:1 Advanced VLSI Circuits</td>
</tr>
<tr>
<td>E0 284 (AUG) 2:1</td>
<td>E8 262 (JAN) 3:0 CAD for High Speed Chip-Package Systems</td>
</tr>
<tr>
<td>E7 211 (JAN) Photonics Integrated Circuits</td>
<td></td>
</tr>
</tbody>
</table>

B. Minor in Photonics

Requirements:

• Any 3 of the courses listed below under Pools X & Y
• with at least one course from Pool X will qualify a student for a “Minor in Photonics”.

<table>
<thead>
<tr>
<th>Pool X</th>
<th>Pool Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>NE 213/E7 213 (AUG) 3:0</td>
<td>E7 211 (JAN) 3:0 Photonics Integrated Circuits</td>
</tr>
<tr>
<td>E8 203 (AUG) 3:0</td>
<td>E3 214 (AUG) 3:0 Microsensor Technologies</td>
</tr>
<tr>
<td>E7 231 (JAN) 3:0</td>
<td>IN 247 (JAN) Principles of Tomographic</td>
</tr>
</tbody>
</table>
C. **Minor in Radio-Frequency Systems**

Requirements:

- Any 3 of the courses listed below under Pools X & Y
- with at least one course from Pool X will qualify a student for a “Minor in Radio-Frequency Systems”.

<table>
<thead>
<tr>
<th>Pool X</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>E8 242 (JAN) 2:1 Radio Frequency Integrated Circuits and Systems</td>
<td></td>
</tr>
<tr>
<td>E3 237 (JAN) 3:0 Integrated Circuits for Wireless Communication</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pool Y</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>E8 202 (AUG) 2:1 Computational Electromagnetics</td>
<td></td>
</tr>
<tr>
<td>E8 203 (AUG) 3:0 RF &amp; Optical Engineering (proposed new course)</td>
<td></td>
</tr>
<tr>
<td>E8 262 (JAN) 3:0 CAD for High Speed Chip-Package Systems</td>
<td></td>
</tr>
</tbody>
</table>

D. **Minor in Signal Processing**

Requirements:

- Any 3 of the courses listed below under Pools X & Y
- with at least one course from Pool X will qualify a student for a “Minor in Signal Processing”.

<table>
<thead>
<tr>
<th>Pool X</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>E9 202 (JAN) 3:0 Advanced Digital Signal Processing: Non-linear Filters</td>
<td></td>
</tr>
<tr>
<td>E9 211 (JAN) 3:0 Adaptive Signal Processing</td>
<td></td>
</tr>
<tr>
<td>E9 212 (JAN) 3:0 Spectrum Analysis</td>
<td></td>
</tr>
<tr>
<td>E9 213 (JAN) 3:0 Time-Frequency Analysis</td>
<td></td>
</tr>
<tr>
<td>E9 221 (AUG) 3:0 Signal Quantization and Compression</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pool Y</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>E1 213 (JAN) 3:1 Pattern Recognition and Neural Networks</td>
<td></td>
</tr>
<tr>
<td>E1 216 (JAN) 3:1 Computer Vision</td>
<td></td>
</tr>
<tr>
<td>E9 203 (JAN) 3:0 Compressed Sensing and Sparse Signal Processing</td>
<td></td>
</tr>
<tr>
<td>E9 231 (AUG) 3:0 Digital Array Signal Processing</td>
<td></td>
</tr>
<tr>
<td>E9 241 (AUG) 2:1 Digital Image Processing</td>
<td></td>
</tr>
<tr>
<td>E9 252 (AUG) 3:0 Mathematical Methods and Techniques in Signal Processing</td>
<td></td>
</tr>
<tr>
<td>E9 261 (AUG) 3:1 Speech Information Processing</td>
<td></td>
</tr>
<tr>
<td>E9 262 (JAN) 3:0 Stochastic Models for Speech/Audio</td>
<td></td>
</tr>
</tbody>
</table>
M-Tech Microelectronics and VLSI Design Program’s course / curriculum

Course and Project Credit: The core and soft-core courses are listed in the table below. Most of the courses have a serious lab component. The credit distribution is summarized as follows:

A. **Core courses (18 credits):** There are 6 courses (mix of 1:2, 2:1 and 3:0 credits) that are mandatory for M. Tech students.

B. **Soft Core (9 credits):** There are total 9 soft core courses, which directly fall under the scheme of Microelectronics and VLSI Design. Students must credit minimum 3 courses from this pool.

C. **Electives (9 credits):** The remaining 9 credits of coursework may be completed by crediting courses listed in the Scheme of Instructions. It's worth highlighting that our faculties offer over 10 different relevant courses, other than what is listed below, from which students can fulfill the elective requirements. Students can also credit soft cores (beyond 9 credits) to fulfill elective requirement.

D. **Project (28 credits):** This is a 1-year project (2 semesters including the summer terms).

<table>
<thead>
<tr>
<th>#</th>
<th>Course No.</th>
<th>Course title</th>
<th>Nature</th>
<th>Term</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>E3 282</td>
<td>Basics of Semiconductor Devices and Technology</td>
<td>Core</td>
<td>August</td>
</tr>
<tr>
<td>2</td>
<td>E3 220</td>
<td>Foundations of Nanoelectronics Devices</td>
<td>Core</td>
<td>August</td>
</tr>
<tr>
<td>3</td>
<td>E3 200</td>
<td>Microelectronics Lab</td>
<td>Core</td>
<td>August</td>
</tr>
<tr>
<td>4</td>
<td>E0 284</td>
<td>Digital VLSI Circuit</td>
<td>Core</td>
<td>August</td>
</tr>
<tr>
<td>5</td>
<td>E3 238</td>
<td>Analog VLSI Circuits</td>
<td>Core</td>
<td>August</td>
</tr>
<tr>
<td>6</td>
<td>E3 231</td>
<td>Digital Systems Design with FPGAs</td>
<td>Soft Core</td>
<td>Jan</td>
</tr>
<tr>
<td>7</td>
<td>E3 275</td>
<td>Physics and Design of Transistors</td>
<td>Soft Core</td>
<td>Jan</td>
</tr>
<tr>
<td>8</td>
<td>E3 280</td>
<td>Carrier Transport in Nanoelectronics Devices</td>
<td>Soft Core</td>
<td>Jan</td>
</tr>
<tr>
<td>9</td>
<td>E3 225</td>
<td>Art of Compact Modelling</td>
<td>Soft Core</td>
<td>August</td>
</tr>
<tr>
<td>10</td>
<td>E7 214</td>
<td>Optoelectronic Devices</td>
<td>Soft Core</td>
<td>Jan</td>
</tr>
<tr>
<td>11</td>
<td>E3 237</td>
<td>Integrated Circuits for Wireless Communication</td>
<td>Soft Core</td>
<td>Jan</td>
</tr>
<tr>
<td>12</td>
<td>E3 245</td>
<td>Processor System Design</td>
<td>Soft Core</td>
<td>August</td>
</tr>
<tr>
<td>13</td>
<td>E8 242</td>
<td>RF IC and Systems</td>
<td>Soft Core</td>
<td>Jan</td>
</tr>
<tr>
<td>14</td>
<td>E8 202</td>
<td>Computational Electromagnetics</td>
<td>Soft Core</td>
<td>August</td>
</tr>
<tr>
<td>15</td>
<td>E7 211</td>
<td>Photonic Integrated Circuits</td>
<td>Soft Core</td>
<td>Jan</td>
</tr>
<tr>
<td>16</td>
<td>E3 274</td>
<td>Design of Power Semiconductor Devices</td>
<td>Soft Core</td>
<td>Jan</td>
</tr>
<tr>
<td>17</td>
<td>E3 271</td>
<td>Reliability of Nanoscale Circuits and Systems</td>
<td>Soft Core</td>
<td>Jan</td>
</tr>
</tbody>
</table>
E1 245 (AUG) 3:0

Online Prediction and Learning

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

Aditya Gopalan

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

Pre-requisites:
• A basic course on probability or random processes

E1 396 (AUG) 3:0

Topics in Stochastic Approximation Algorithms

Introduction to Stochastic approximation algorithms, ordinary differential equation based convergence analysis, stability of iterates, multi-timescale stochastic approximation, asynchronous update algorithms, gradient search based techniques, topics in stochastic control, infinite horizon discounted and long run average cost criteria, algorithms for reinforcement learning.

Rajesh Sundaresan

References:
• Relevant research papers.

Pre-requisites:
• Random Processes (E2 202) or Probability and Statistics (E0 232) or equivalent

E2 201 (AUG) 3:0

Information Theory

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

Himanshu Tyagi

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.

Utpal Mukherji, Parimal Parag

References:
• B. Hajek, An Exploration of Random Processes for Engineers, Course Notes, 2009,
• A. Kumar, Discrete Event Stochastic Processes, Online book,

E2 205 (AUG) 3:0
Error-Control Coding
Basics of binary block codes; mathematical preliminaries: groups, rings, fields and vector spaces; convolutional codes and the Viterbi algorithm; belief propagation with application to the decoding of codes; LDPC codes; finite fields, Reed-Solomon and BCH codes.

Vijay Kumar P

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

E2 211 (AUG) 3:0
Digital Communication
Representation of signals and systems; Digital modulation techniques and their performance in AWGN channel; optimum receiver structures for AWGN channel; signal design for band-limited and power-limited channels; power and bandwidth efficiency tradeoff; coding and coded modulation techniques – capacity approaching schemes; ISI and equalization; Multichannel and multicarrier systems; Digital communications through fading multipath channels.

Sundar Rajan B

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

E2 212 (AUG) 3:0
Matrix Theory

Ramakrishnan A G
References:

E2 214 (AUG) 3:0
Finite-State Channels
Basic definitions; information-theoretic capacity and channel coding theorems; the Gilbert-Elliott channel; memoryless channels with input constraints; feedback capacity and its dynamic programming formulation; posterior matching schemes for achieving feedback capacity

Navin Kashyap

References:
- Relevant journal papers

Pre-requisites:
- E2 201 (Information theory)

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.

Chockalingam A

References:

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-prefix 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 communications (VLC); transmitter, channel, receiver, performance, MIMO-VLC.

Chockalingam A
References:

• Research papers

E2 302 (AUG) 3:0
Next Generation Wireless Systems: Design and Analysis

Theory, design techniques, and analytical tools for characterizing next generation wireless systems. Performance analysis of digital communication systems over fading channels, rate and power adaptation, and multi-user diversity techniques; Study of LTE standard, its air interface, physical and logical channels, and physical layer procedures. Survey of advanced technologies such as cooperative communications and cognitive radio.

Neelesh B Mehta

Pre-requisites:

• E2 211 “Digital Communications”

E2 331 (AUG) 3:0
Advanced Topics in Coding Theory

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

Sundar Rajan B

Pre-requisites:

• linear algebra (matrix theory) and probability theory, at a graduate, or at least senior undergraduate, level.

E2 336 (AUG) 3:0
Foundations of Machine Learning


Vinod Sharma, Parimal Parag

References:

• Foundations of machine learning, Mehryar Mohri, Afshin Rostamizadeh, and Ameet Talwalkar
• Understanding Machine Learning, Shai Shalev-Shwartz and Shai Ben-David

Pre-requisites:

• Random processes
E3 220 (AUG) 3:0

 Foundations of Nanoelectronic Devices

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

Kausik Majumdar

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
- N. W. Ashcroft and N. D. Mermin, Solid State Physics
- S. M. Sze, Physics of Semiconductor devices
- Y. Taur and T. H. Ning, Fundamentals of modern VLSI devices

E3 238 (AUG) 2:1

 Analog VLSI Circuits


Gaurab Banerjee

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

E7 221 (AUG) 2:1

 Fiber-Optic Communication

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

Shivaleela E S, Srinivas T

References:
E8 202 (AUG) 2:1

**Computational Electromagnetics**

Maxwell’s equations, Wave equations, scalar and vector potentials, fundamental theorems in EM Method of moments: Greens Functions; Surface equivalence principle; Electrostatic formulation; Magnetoostatic 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++)

Vinoy K J, Dipanjan Gope

References:

E9 206 (AUG) 3:0

**Digital Video: Perception and Algorithms**

The course will cover algorithms for digital video processing from the point of view of human visual perception. Topics include video sampling, frequency response of human visual systems, color perception, video transforms, retinal and cortical filters (difference of Gaussians, Laplacian of Gaussians, center-surround responses, 3D Gabor filterbanks, steerable pyramids), motion detection, Reichardt detector, optical flow algorithms (Horn-Schunck, Black-Anandan, Fleet-Jepson, optical flow in the brain, block motion), video compression, statistical video models (spectrum power law, divisive normalization, Gaussian scale mixtures, optical flow statistics, Weber-Fechner law), video quality assessment, stereopsis, denoising, foveation and saliency.

Rajiv Soundararajan

References:

E9 211 (AUG) 3:0

**Adaptive Signal Processing**


Sundeep Prabhakar Chepuri

References:
Detection and Estimation Theory


Sundeep Prabhakar Chepuri

References:

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

References:

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

References:

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

References:

E2 242 (JAN) 3:0
Multiuser Detection


Chockalingam A

References:
• Research Papers in Journals and Conferences

E2 330 (JAN) 3:0
Statistical Physics Methods in Information Theory and Coding

The aim of the course is to introduce a range of tools, tricks and jargon from statistical physics that are useful in information and coding theory. The topics to be covered in the course are: The basic statistical physics models: Lattice gas, Ising, spin glasses; formulation of inference problems as spin glass models; Exactly solvable models: Curie-Weiss, and Ising on a tree Message passing algorithms: Belief propagation and variants, approximate message passing Partition functions and their computation

Navin Kashyap

References:
• Marc Mezard and Andrea Montanari (2009), Information, Physics and Computation, Oxford Univ. Press.
• Selected journal papers

Pre-requisites:
• E2 205 (Error-Correcting Codes)
E3 237 (JAN) 3:0
Integrated Circuits for Wireless Communication

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

Gaurab Banerjee

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

Pre-requisites:
- Analog VLSI Circuits E3 238

E7 211 (JAN) 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

Srinivas T, Varun Raghunathan

References:
- Current literature: Special issues of journals and review articles

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 (responsitivity, gain and speed), and noise processes in detection. Light modulation: Electro-optic devices, amplitude and phase modulation, Franz-Keldysh effect, quantum confined stark effect. Review of current topics in optoelectronics: heterogeneously integrated lasers, thermo-photo voltaic devices, silicon photonics, Germanium lasers, SPASERS, Polariton lasers etc. 3-4 homeworks, one midterm, one final and a group
project are intended as means of evaluating the students.

Varun Raghunathan

References:


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

References:

• D M Pozar, Microwave Engineering, John Wiley 2003.
• D M Pozar., Microwave and RF Wireless Systems.
• V K Varadan, K. J Vinoy, K.A Jose, RF MEMS and Their Applications.

E8 262 (JAN) 3:0
CAD for High Speed Chip-Package-Systems

Dipanjan Gope

E9 203 (JAN) 3:0
Compressed Sensing and Sparse Signal Processing


Chandra R Murthy

References:

Pre-requisites:
- Random Processes, Matrix Theory.

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

References:

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

References:
- Current literature

Pre-requisites:
- Digital Communication, Introduction to Space-Time Wireless Communications,

EP 299 (JAN) 0:28
Project

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.

Navin Kashyap
Department of Electrical Engineering

The department of Electrical Engineering at Indian Institute of Science offers a vibrant environment for postgraduate education and research in Electrical Engineering. Established in 1911, it is one of the first few departments at IISc. The vision of the department is to provide the leadership to enable India's excellence in the field of Electrical Engineering. The department is committed to advancement of the frontiers of knowledge in Electrical Engineering and to provide the students with a stimulating and rewarding learning experience.

The department is currently engaged in research in many areas of Electrical Engineering including Power Systems, Energy Studies, Power Electronics, Electrical Drives, High Voltage engineering, Signal Processing, Image Processing and Multimedia, Biomedical Imaging, Machine Learning, Pattern Recognition, etc.

The department admits students for 2-year M Tech programs as well as research programs leading to Ph.D. and M Tech(Res) degrees.

The department is recognized as a Center for Advanced Studies in Electrical Engineering by University Grants Commission.

The department of Electrical Engineering offers three masters programs based on course work.

- M Tech - Electrical Engineering
- M Tech - Artificial Intelligence, offered by Division of Electrical, Electronics and Computer Science
- M Tech - Signal Processing offered jointly with department of Electrical Communications Engineering

Students with a bachelor's degree in relevant engineering disciplines are eligible for admission. The admission is based on the GATE score, Written test and Interview for MTech (EE) and MTech (AI) Programmes and GATE score and Interview for MTech (SP) Programme. Details regarding specific eligibility criteria for the different MTech degrees and procedure for application etc. are available in the Admission Brochure.

For more details, please visit [http://www.ee.iisc.ac.in](http://www.ee.iisc.ac.in)
E0 247 (AUG) 3:1

Sensor Networks

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

Rathna G N

References:

Pre-requisites:
• Consent of Instructor

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.

Kunal Narayan Chaudhury

References:

Pre-requisites:
• none.

Co-requisites:
• none.

E1 222 (AUG) 3:0

Stochastic Models and Applications

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

Subbayya Sastry P

References:
E1 241 (AUG) 3:0

Dynamics of Linear Systems


Pavankumar Tallapragada

References:

Co-requisites:
• (Linear algebra or equivalent) OR (Permission of the instructor) AND (Basic knowledge of linear ODEs)

E1 251 (AUG) 3:0

Linear and Nonlinear Optimization

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

Muthuvel Arigovindan

References:

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.

Jayachandra Shenoy U

References:
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-low frequency oscillations – methods of analysis for single and multi-machine systems, power system stabilizers.

Gurunath Gurrala

References:

E4 234 (AUG) 3:0
Advanced Power Systems Analysis

Sarasij Das

References:

E5 201 (AUG) 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.

Subba Reddy Basappa, Rajanikanth B S

References:
• References: Kuffel E
• Zaengl W S
• Kuffel J
• High Voltage Engineering- Fundamentals
• Newnes
E5 213 (AUG) 3:0
EHV/UHV Power Transmission Engineering
E4 213 (Aug) 3:0 EHV/UHV Power Transmission Engineering Electrical power transmission by HVAC and HVDC, overhead transmission lines, bundled conductors, mechanical vibration of conductors, surface voltage gradient on conductors, corona & associated power loss, radio-noise and audio-noise & their measurement, fields under transmission lines, overhead line insulators, insulator performance in polluted environment, EHV cable transmission - underground cables and GIL, high voltage substations-AIS and GIS, grounding of towers and substations, over voltages in power systems, temporary, lightning and switching over voltages, design of line insulation for power frequency voltage, lightning and switching over voltages, insulation co-ordination.

Joy Thomas M

References:
• Transmission line Reference Book 345 kV & above, Electrical Power Research Institute, (EPRI), 1982 USA.

E5 215 (AUG) 2:1
Pulsed Power Engineering_ *
Overview of Pulsed Power Engineering, pulsed power generators, PFN schemes, Marx circuits, Magnetic pulse compression, power conditioning systems, measurement techniques or pulsed power parameters, insulation requirements for pulsed power systems, specific insulation systems used in pulsed power systems - gaseous, liquid, solid and magnetic insulation and their behaviour under pulsed voltages, Applications of pulsed power systems, pulsed power systems for high power lasers, Lightning, NEMP and ESD simulators, HPM, IRA, coilgun and railgun applications, pulsed power systems for biological and pollution control applications.

Joy Thomas M

References:
• Current literature from journals and conference proceedings

E5 253 (AUG) 2:1
Dielectrics and Electrical Insulation Engineering_ *

Joy Thomas M

E6 201 (AUG) 3:1
Power Electronics
Power switching devices: diode, BJT. MOSFET, IGBT; internal structure, modeling parameters, forward characteristics and switching characteristics of power devices; control and protection of power switching devices; electromagnetic elements and their design; choppers for dc to dc power conversion; single and multi-quadrant operation of choppers; chopper controlled dc drives; closed loop control of dc drives. Hands-on exercises: soldering and desoldering practice, pulse generator circuit, inductor design and fabrication, thermal resistance of heat sink, switching characteristics of MOSFET, dc-dc buck converter, CCM and DCM operation, linear power supply, output voltage feedback for over-current protection, dc-dc boost converter, measurement of small-signal transfer functions, closed loop control of boost converter.
Narayanan G

References:

E6 224 (AUG) 3:0
Topics in Power Electronics and Distributed Generation

Introduction to distribution systems, fault calculations, fault contribution and protection coordination with DG, distribution systems grounding, impact of DG on grounding, intentional and unintentional islanding, dynamic phasor modelling and detection methods, relaying requirements for DG systems. Online tap changes, series voltage regulators, feeder voltage control and voltage profile, ring feeders and network distribution. Economic considerations for DG systems, cost of energy and net present cost calculations. Power converters for grid interconnection for single phase and three phase systems. Voltage source inverter design issues, DC bus capacitor design selection, reliability and lifetime, power semiconductor component selection and design for efficiency and reliability, filtering requirements. Noise considerations in power electronic systems, coupling mechanism, common mode and differential mode analysis of power electronics circuits and circuit symmetry, self and external shielding, filtering and referencing of circuits. Control requirements for DG.

Vinod John

References:
- IEEE papers and standards, datasheets, current literature.

Pre-requisites:
- None (Students are expected to be familiar with power electronics)

E6 225 (AUG) 3:0
Advanced Power Electronics


Kaushik Basu

References:

Pre-requisites:
- E6 201: Power Electronics or E6 202: Design of Power Converters
**E8 201 (AUG) 3:0**

**Electromagnetism**

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

*Udaya Kumar*

References:

**E9 201 (AUG) 3:0**

**Digital Signal Processing**

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

*Soma Biswas, Prasanta Kumar Ghosh*

References:
- Proakis and Manolakis, Digital Signal Processing, Prentice Hall India.

**E9 205 (AUG) 3:1**

**Machine Learning for Signal Processing**


*Sriram Ganapathy*

References:

Pre-requisites:
- Random Process / Probability and Statistics
- Linear Algebra / Matrix Theory
E9 241 (AUG) 2:1

Digital Image Processing

Continuous image characterization, sampling and quantization, 2D Fourier transform and properties, continuous/discrete image processing, rotation, interpolation, image filtering (shift-invariant filters, bilateral filters, nonlocal means), spatial operators, morphological operators, edge detection, texture, 2-D transforms (discrete Fourier transform, discrete cosine transform, Karhunen-Loève transform, wavelet transform), image pyramid, image denoising, segmentation, restoration.

Chandra Sekhar Seelamantula, Rajiv Soundararajan

References:

E9 245 (AUG) 3:1

Selected Topics in Computer Vision

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

Srinivasa Venu Madhav Govindu

References:

Pre-requisites:
• E1 216 or permission of the instructor.

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 Beagle and xilinx FPGA boards.

Rathna G N

References:
• References: Rulph Chassaing, Digital signal processing and applications with C6713 and C6416 DSK, Wiley, 2005, Keshab K Parhi

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

References:

E0 265 (JAN) 3:1
Convex Optimization and Applications


Kunal Narayan Chaudhury

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

References:

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

References:
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 time implementation, 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

References:
- Erickson R W and Maksimovic D, Fundamentals of Power Electronics, Springer.

Pre-requisites:
- Under graduate level analog electronics, digital electronics and classical feedback control theory. Familiarity with micro-processor, digital signal processing, power electronics (E6 201) previous experience in programming will be helpful but not a necessity.

E4 233 (JAN) 3:0
Computer Control of Power Systems

Gurunath Gurrala

E4 237 (JAN) 2:1
Selected Topics in Integrated Power Systems


Gurunath Gurrala

References:
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

References:

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

Satish L, Rajanikanth B S, Udaya Kumar

References:

Over voltages in Power Systems

Transient phenomena on transmission lines, methods of analysis and calculation, use of PSPICE, principle of EMTP lightning discharges, origin and characteristics 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

References:
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

References:

E5 213 (JAN) 3:0
EHV/UHV Power Transmission Engineering

Joy Thomas M

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

References:

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
References:

E6 223 (JAN) 3:0

**PWM Converters and Applications**

AC/DC and DC/AC power conversion. Overview of applications of voltage source converters, pulse modulation techniques for 1-phase and 3-phase bridges; bus clamping PWM, space vector based PWM, advanced PWM techniques, practical devices in converter. Calculation of switching and conduction losses. Compensation for dead time and DC voltage regulation; dynamic model of a PWM converter, multilevel converters; constant V/F induction motor drives; estimation of current ripple and torque ripple in inverter fed drives. Line-side converters with power factor compensation.

Narayanan G

References:

E9 213 (JAN) 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 moments, regularity, Lipschitz regularity, Fix-Strang conditions, compact support, Shannon, Meyer, Haar and Battle-Lemarié wavelets, Daubechies wavelets, relationship between wavelets and filterbanks, perfect reconstruction filterbanks.

Chandra Sekhar Seelamantula

References:

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

**Soma Biswas, Rajiv Soundararajan**

**References:**

**Pre-requisites:**
- E9 241: Digital Image Processing

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**E9 261 (JAN) 3:1**

**Speech Information Processing**


**Prasanta Kumar Ghosh, Sriram Ganapathy**

**References:**
- Recent literature.

**Pre-requisites:**
- E9-201 or consent of the instructor.

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**E9 282 (JAN) 2:1**

**Neural Signal Processing**

Biophysics and computational techniques for the analysis of action potentials, Local Field Potential (LFP), Electrocoriticoencephalogram (ECOG/EEG) and functional Magnetic Resonance Imaging (fMRI). Techniques include stochastic processes, self organized criticality, time-frequency analysis, sparse signal processing, coherence, information theoretic methods, ICA/PCA, forward and inverse modeling, directed transfer functions, Granger causality, image processing methods and reverse correlation.

**Chandra Sekhar Seelamantula, Supratim Ray**

**References:**
E9 285 (JAN) 3:0

Biomedical imaging - Inverse problems


Muthuvel Arigovindan

Pre-requisites:
- Selected paper from recent literature
- Should have taken a linear algebra course
- Basic calculus will be needed

E9 292 (JAN) 2:1

Real-Time Signal Processing with DSP

Implementation of discrete-time systems, DSP device architecture and programming (TMS320C6x), FIR/IIR digital filter design, Multirate DSP, Power spectrum estimation, Linear prediction and adaptive filtering, Real-time system development, DSP Programming, Code Composer Studio and DSP BIOS, Spawning and controlling tasks and data I/O, Real-time scheduling analysis, load analysis, Queues, semaphores and mailboxes, Real-time data exchange using Lab view, Mini Project.

Rathna G N

Pre-requisites:
- Knowledge of Digital Signal Processing, Nasser kehtarnawaz, Real-Time Digital Signal Processing based on TMS320C6000, TMS320C6x Data Sheets from TI

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

References:

Pre-requisites:
- One or more of: NS201: Fundamentals of Systems and Cognitive Neuroscience;
- E9 282: Neural Signal Processing; E9 201 : Digital Signal Processing
- E1 213: Pattern Recognition and Neural Networks; E0 270: Machine Learning
Dissertation Project (SE)

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.

E6 226 (MAY) 3:0

Switched Reluctance Machines and Drives

# DEPARTMENT OF ELECTRONIC SYSTEMS ENGINEERING
## M Tech Programme
### ELECTRONIC SYSTEMS ENGINEERING

<table>
<thead>
<tr>
<th>Duration: 2 Years</th>
<th>Total Credits: 64</th>
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**Core Courses: 18 credits (All courses are compulsory)**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>E0 284</td>
<td>Digital VLSI Circuits</td>
</tr>
<tr>
<td>E2 243</td>
<td>Mathematics for Electrical Engineers</td>
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<tr>
<td>E3 235</td>
<td>Design for Analog Circuits</td>
</tr>
<tr>
<td>E3 262</td>
<td>Electronic Systems Packaging</td>
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<tr>
<td>E3 282</td>
<td>Basics of Semiconductor Devices and Technology</td>
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<tr>
<td>E6 202</td>
<td>Design of Power Converters</td>
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</tbody>
</table>

**Electives: 21 Credits** (all at 200 level or higher) from the following courses or any other courses listed in the Scheme of Instructions.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>E1 243</td>
<td>Digital Controller Design</td>
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<tr>
<td>E1 261</td>
<td>Selected Topics in Markov Chains and Optimization</td>
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<tr>
<td>E2 222</td>
<td>Data Center Networking</td>
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<td>E2 230</td>
<td>Network Science and Modeling</td>
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<td>E2 231</td>
<td>Topics in Statistical Methods</td>
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<td>E2 232</td>
<td>TCP-IP Networking</td>
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<td>E3 225</td>
<td>Art of Compact Modeling</td>
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<td>E3 231</td>
<td>Digital System Design with FPGAs</td>
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<td>E3 233</td>
<td>VLSI for Signal Processing</td>
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<td>E3 245</td>
<td>Processor System Design</td>
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<td>E3 257</td>
<td>Embedded System Design</td>
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<td>E3 258</td>
<td>Design for Internet of Things</td>
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<td>E3 271</td>
<td>Reliability of Nanoscale Circuits and Systems</td>
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<tr>
<td>E3 272</td>
<td>Advanced ESD Devices, Circuits and Design Methods</td>
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<td>E3 274</td>
<td>Design of Power Semiconductor Devices</td>
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<td>E6 212</td>
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<td>E9 251</td>
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<td>E9 252</td>
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<td>E9 253</td>
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</table>

**Project: 25 Credits**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Credits</th>
<th>Title</th>
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<tbody>
<tr>
<td>EP 299</td>
<td>0:25</td>
<td>Dissertation Project</td>
</tr>
</tbody>
</table>
E0 284 (AUG) 2:1
Digital VLSI Circuits

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

Chetan Singh Thakur

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

E2 230 (AUG) 3:0
Network Science and Modeling

Introduction to main mathematical models used to describe large networks and dynamical processes that evolve on networks. Static models of random graphs, preferential attachment, and other graph evolution models, Epidemic propagation, opinion dynamics, and social learning, Applications drawn from physical, informational, biological, cognitive, and social systems as well as networked decision systems such as Internet

Chandramani Kishore Singh

References:
• D. Easley and J. Kleinberg, Networks, Crowds and Markets
• Current Literature

Pre-requisites:
• Random Processes or Stochastic Models and Applications or any equivalent course

Co-requisites:
• none

E2 232 (AUG) 2:1
TCP/IP Networking

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

Prabhakar T V, Dagale Haresh Ramji, Joy Kuri

References:

E2 243 (AUG) 2:1
Mathematics for Electrical Engineers

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

Chandramani Kishore Singh

References:
• Rudin, W., Principles of Mathematical Analysis, McGraw-Hill, 1985

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

Mayank Shrivastava

E3 235 (AUG) 2:1

Design for Analog Circuits


Umanand L

References:
• Gray, Hurst, Lewis, and Meyer, Analysis and Design of Analog Integrated Circuits, John Wiley & Sons, 5th edition,
E3 245 (AUG) 2:1
**Processor System Design**


**Kuruvilla Varghese**

**References:**
- Computer Organization and Design: The Hardware/Software Interface, The Morgan Kaufmann, By David A. Patterson and John L. Hennessy
- Current Literature

**Pre-requisites:**
- E0 284 Digital VLSI Circuits
- E3 231 Digital System Design with FPGAs

E3 260 (AUG) 2:1
**Embedded System Design – II**

Review of an embedded system without OS, Software components: startup code, boot loader, kernel, applications. Realtime concepts for embedded systems, Basic OS constructs Semaphores, Mutex, Queues, Tasks, and Scheduler, Introduction to a real-time kernel, scheduling policies, mutual exclusion, and synchronization, inter-task control flow, inter-task data flow, memory management, interrupt processing. Linux for embedded applications: an overview of Linux kernel architecture; system call interface. Process management; memory management; file system architecture. Linux for micro-controllers and real-time applications. Device driver: character, block and network drivers. Designing a real-time system: development life cycle, modeling a real-time system, Case studies.

**Dagale Haresh Ramji**

**References:**
- Real Time Concepts for Embedded Systems by Qing Li and Caroline Yao, ELSEVIER
- Embedded Systems - Real-Time Operating Systems by Jonathan W. Valvano
- Understanding Linux Kernel by Bovet, D., and Cesati, M. O'Reilly Publication

E3 262 (AUG) 2:1
**Electronic Systems Packaging**

Electronic systems and needs, physical integration of circuits, packages, boards and complete electronic systems; system applications like computer, automobile, medical and consumer electronics with case studies and packaging levels. Electrical design considerations - power distribution, signal integrity, RF package design and Power-delivery in systems. CAD for Printed Wiring Boards (PWBs) and Design for Manufacturability (DFM). PWB Technologies, Single-chip (SCM) and Multi-chip modules (MCM), flex circuits. Recent trends in manufacturing like microvias, sequential build-up circuits and high-density interconnect structures. Materials and processes in electronics packaging, joining methods in
electronics; lead-free solders. Surface Mount Technology – design, fabrication and assembly, embedded passive components; thermal management of PWBs, thermo-mechanical reliability, design for reliability, electrical test and green packaging issues, Assignments in PCB CAD; Hands-on lab sessions for board manufacturing and assembly.

Mahesh G V

References:

E3 282 (AUG) 3:0
Basics of Semiconductor Devices and Technology

Introduction to semiconductor device physics: Review of quantum mechanics, electrons in periodic lattices, E-k diagrams, quasiparticles (electrons, holes and phonons) in semiconductors. Carrier statics and dynamics, carrier transport under low electric and magnetic fields: Mobility and diffusivity; Carrier statistics; Continuity equation, Poisson’s equation and their solution. High field effects: Velocity saturation, hot carriers and avalanche breakdown. Semiconductor Junctions: Schottky, p-n junction and hetero-junctions and related physics. Ideal and nonideal MOS capacitor, band diagrams and CVs; Effects of oxide charges, defects and interface states; Characterization of MOS capacitors: HF and LF CVs. Physics of transistors

Mayank Shrivastava

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

E2 231 (JAN) 3:0
Topics in Statistical Methods

Random Walks on Graphs – main parameters, the eigenvalue connection, the electrical connection, mixing rate, sampling by random walks, Markov random fields, Gibbs sampling, Markov chain Monte Carlo, Metropolis Hastings, Simulated annealing, Belief propagation, Bethe free energy, Kikuchi approximation, generalized belief propagation, convergence of belief propagation, Cavity method, Correlation decay, Learning Graphical models.

Chandramani Kishore Singh

References:

E3 225 (JAN) 3:0
Compact Modeling of Devices

Band theory of solids, carrier transport mechanism, P-N junction diode, MOS Capacitor Theory, C-V characteristics, MOSFET operation, Types of compact models, Input Voltage Equation, Charge Linearization, Charge Modeling, Concept of Core Model, Quasi-static and Non-quasi-static Model, Introduction to Verilog-A, Basic theory of circuit simulation, Brief overview of EKV and PSP

Santanu Mahapatra
References:
- Tsividis, Y., Operation and Modelling of the MOS Transistor, Oxford University Press, 2012

**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, Xilinx 7 Series FPGA architecture, programming FPGA, constraints, STA, timing closure, case study.

Kuruvilla Varghese

References:
- VHDL for Programmable Logic, By Kevin Skahill, Pearson
- FPGA Data Sheets, Application Notes
- Current Literature

**E3 257 (JAN) 2:1**

**Embedded System Design - I**

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

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

**E3 258 (JAN) 2:1**

**Design for Internet of Things**

Embedded Systems: Rise of embedded systems and their transition to intelligent systems and to Internet of Things - RFID, NFC, Web of Things - Network of interconnected and collaborating objects, Embedded systems architecture: Key hardware and software elements, typical embedded processors like ATOM. Low power and very low power embedded systems, peripherals and sensors in embedded systems, peripheral interfacing - SPI and I2C, Hardware and software protocol stacks - MAC, Routing and application layers, performance considerations. Embedded Systems Design: Partitioning to hardware and software; principles of co-design; performance of these systems - estimation of speed, throughput, power and energy consumption; hardware design elements - design, validation, and testing tools; software platforms – OS and applications, code optimization, validation and robust code generation; system integration, debugging and test methodology; tools for coding, debugging, optimization, and documentation; measurement of system performance, Linux distributions for embedded systems using tools from Yocto project; Creating virtual prototypes - hardware software emulation. Applications: Healthcare and home automation examples.

Prabhakar T V
E3 271 (JAN) 1:2
Reliability of Nanoscale Circuits and Systems

Carrier transport and carrier energy fundamentals, avalanche multiplication and breakdown, hot carrier induced (HCI) degradation mechanism, NBTI/PBTI, TDDB, GOI and Electromigration, ESD and latch-up phenomena, Test models and methods, ESD protection devices and device physics, Advance ESD protection devices, high current effects and filaments, Negative differential resistance, Physics of ESD failure, ESD protection methodology, ESD protection circuits, ESD protection for Analog/RF and mixed signal modules, General rules for ESD design, layout considerations for ESD and latch-up protection, understanding parasitics, ESD circuit simulation basics and requirements, ESD TCAD simulation methodology, System on Chip overview and system ESD aspects, case studies related to product failures and solutions use

Mayank Shrivastava

E3 274 (JAN) 1:2
Design of Power Semiconductor Devices

Power device applications: Power electronic applications, High voltage and high-power circuits, RF power circuits and applications, On-chip circuits and power management system, high switching speed requirements for power system scaling. Semiconductor Physics under extreme conditions: Basics of semiconductor device physics, p-n junction, carrier transport under extreme conditions, avalanche breakdown, and thermal transport. Power Diodes: Various types of power diodes: Si diodes, Schottky diodes and P-i-N diodes; Physics of power diodes, power diode design essentials, breakdown voltage and ON-resistance trade-off, high current and ultra fast transient behavior. Si High Power MOS devices, design and Technology: VMOS, VDMOS, UMOS, DMOS, LDMOS, DeMOS and Dual trench MOS; Process flow, discrete and On-chip device manufacturing technology; High power MOS design essentials, breakdown voltage and on-resistance trade-off, parasitic capacitance and resistances, DC, RF and switching characteristics; quasi saturation behavior, high current effects, Negative differential resistance (NDR), self heating, filament formation and safe operating area (SOA). GaN and SiC Power MOS devices: Advantage of high bandgap materials, High bandgap material physics, various GaN/SiC devices, device physics and design essentials, GaN/SiC device manufacturing technology; breakdown voltage and on-resistance trade-off, parasitic capacitance and resistances, DC, RF and switching characteristics; quasi saturation behavior, self heating effects and safe operating area (SOA); state-of-the-art GaN/SiC devices and ongoing research. IGBTs and SCR: IGBTs and SCR device physics and device design essentials, breakdown voltage and on-resistance trade-off, self heating effects and filament formation.

Mayank Shrivastava

References:

• High Voltage Devices and Circuits in Standard CMOS Technologies, Hussein Ballan, Michel Declercq
E3 276 (JAN) 2:1

Process Technology and System Engineering for Advanced Microsensors and Devices


Hardik J Pandya

References:
- Fundamentals of Microfabrication by Madou Marc J.
- Silicon VLSI Technology: Fundamentals, Practice, and Modeling by James D. Plummer, Michael Deal, and Peter D. Griffin
- Fundamentals of Semiconductor Fabrication by S M Sze
- VLSI Fabrication Principles: Silicon and Gallium Arsenide by S K Gandhi
- VLSI Technology by S M Sze
- Fundamentals of Microelectronics by B Razavi
Pre-requisites:
• Basic Electronics

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

References:

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

References:

E9 253 (JAN) 3:1
Neural Networks and Learning Systems
Introduction, models of a neuron, neural networks as directed graphs, network architectures (feed-forward, feedback etc.), Learning processes, learning tasks, Perceptron, perceptron convergence theorem, relationship between perceptron and Bayes classifiers, batch perceptron algorithm, modeling through regression: linear, logistic for multiple classes, Multilayer perceptron (MLP), batch and online learning, derivation of the back propagation algorithm, XOR problem, Role of Hessian in online learning, annealing and optimal control of learning rate, Approximations of functions, universal approximation theorem, cross-validation, network pruning and complexity regularization, convolution networks, nonlinear filtering, Cover's theorem and pattern separability, the interpolation problem, RBF networks, hybrid learning procedure for RBF networks, Kernel regression and relationship to RBFs., Support vector machines, optimal hyperplane for linear separability, optimal hyperplane for non-separable patterns, SVM as a kernel machine, design of SVMs, XOR problem revisited, robustness considerations for regression, representor theorem, introduction to regularization theory, Hadamard's condition for well-posedness, Tikhonov regularization, regularization networks, generalized RBF networks, estimation of regularization parameter etc., L1 regularization basics, algorithms and extensions, Principal component analysis: Hebbian based PCA, Kernel based PCA, Kernel Hebbian algorithm, deep MLPs, deep auto-
encoders, stacked denoising auto-encoders

Shayan Garani Srinivasa

References:
• S. Haykin, Neural Networks and Learning Machines, Pearson Press.
• K. Murphy, Machine Learning: A Probabilistic Perspective, MIT Press

Chandramani Kishore Singh
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 administers an Institute characterization facility, ‘Advanced Facility for Microscopy and Microanalysis’. 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 code.

- 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 digits of the course number have the departmental code as the prefix. All the Departments/Centres (except the Space Technology Cell) of the Division provide facilities for research work leading to the degrees of M Tech (Research) and Ph D. 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. M Tech Degree Programmes are offered in all the above departments except in the Centre for Product Design and Manufacturing which offers M.Des. Department of Civil Engg also offers an M Tech Programme in Transportation and Infrastructure Engineering. 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. Vikram Jayaram
Chair
Division of Mechanical Sciences
Aerospace Engineering MTech Curriculum

<table>
<thead>
<tr>
<th>Semester I</th>
<th>Semester 2</th>
<th>Semester 3</th>
<th>Semester 4</th>
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<tr>
<td>Flight and Space Mechanics</td>
<td>Math requirement either in the 2nd or 3rd semester</td>
<td>Aerospace Seminar</td>
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<tr>
<td>Fluid Dynamics</td>
<td>Elective 1</td>
<td>Elective 5</td>
<td></td>
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<tr>
<td>Mechanics and Thermodynamics of Propulsion</td>
<td>Elective 2</td>
<td>Elective 6</td>
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<tr>
<td>Flight Vehicle Structures</td>
<td>Elective 3</td>
<td>Elective 7</td>
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<tr>
<td>Navigation, Guidance and Control</td>
<td>Elective 4</td>
<td>Elective 8</td>
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<tr>
<td>Experimental Techniques in Aerospace Engineering</td>
<td></td>
<td>MTech Dissertation distributed over 3rd and 4th semesters</td>
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<tr>
<td>16 credits</td>
<td>48 credits (Minimum 12 credits per semester)</td>
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The core courses include Flight and Space Mechanics, Fluid Dynamics, Mechanics and Thermodynamics of Propulsion, Flight Vehicle Structures, and Navigation, Guidance and Control.

Math requirement can be math courses offered in the Aerospace Engineering Department, or courses from Math Department IISc, or courses from Center for Data Sciences IISc. A list of courses that fulfills the math requirement will be listed separately by the AE DCC.

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.

Aerospace Seminar is a 1 credit course in the 4th semester. This course will have lectures by AE faculty as well as lectures by staff from Archives and Publications Cell on best practices in scientific written and oral communication. Thereafter the MTech students will present a report and seminar during the 4th semester on a topic chosen in consultation with their faculty advisor. These seminar reports and presentations will be evaluated by an AE faculty panel.

Special Topics in Aerospace Engineering 1 and Special Topics in Aerospace Engineering 2 are two electives of an advanced nature on topics of current research being pursued by AE faculty. These courses will be offered by interested AE faculty. These elective courses will be open to all students in the Institute and pre-requisites for registering for these electives will be with instructor’s consent.

The MTech dissertation project is aimed at training students to analyze 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.

MTech Dissertation adviser to be chosen by the MTech student at the end of the first semester. Math requirement, all electives, and the independent study course, will be credited by a student in consultation with the MTech dissertation adviser. In keeping with IISc MTech program requirement, AE MTech students should register for a minimum of 12 credits per semester.
AE 201 (AUG) 3:0
Flight and Space Mechanics

Ranjan Ganguli

References:

AE 202 (AUG) 3:0
Fluid Dynamics
Properties of fluids, kinematics of fluid motion, conservation laws of mass, momentum and energy, potential flows, inviscid flows, vortex dynamics, dimensional analysis, principles of aerodynamics, introduction to laminar viscous flows.

Ramesh O N

References:

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.

Pratikash Prakash Panda

References:

AE 204 (AUG) 3:0
Flight Vehicle Structures
Introduction to aircraft structures and materials; introduction to elasticity, torsion, bending and flexural shear, flexural shear flow in thin-walled sections; elastic buckling; failure theories; variational principles and energy methods; loads on aircraft.

Debiprosad Roy Mahapatra
References:
- 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.

Debasish Ghose, Ashwini Ratnoo, Suresh Sundaram

References:
- AE NGC Faculty, Lecture Notes.
- Nise, N.S., Control Systems Engineering, 6th edition, John Wiley and Sons Inc

AE 228 (AUG) 2:1
Computation of Viscous Flows

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

Balakrishnan N (CFD)

Pre-requisites:
- AE 227

AE 245 (AUG) 3:0
Advanced Combustion


Santosh Hemchandra

References:
• Unsteady Combustor Physics by T. Lieuwen, Cambridge 2012.
• Recent literature.

Pre-requisites:
• AE 203 or AE 241 or AE 242 or AE 243, or equivalent. These can however be waived after discussion with the course instructors.

AE 256 (AUG) 3:0
Wave Propagation in Structures

Structural dynamics and wave propagation, continuous and discrete Fourier transform, FFT, sampled wave forms, spectral analysis of wave motion, propagating and reconstructing waves, dispersion relations, signal processing and spectral estimation, longitudinal wave propagation in rods, higher order rod theory, flexural wave propagation in beams, higher order beam theories, wave propagation in complex structures, spectral element formulation, wave propagation in two dimensions, wave propagation in plates.

Gopalakrishnan S

References:

AE 261 (AUG) 3:0
Structural Vibration Control


Siddanagouda Kandagal

References:
• Inman, D.J., Vibration with Control, John Wiley, New York, 2006

AE 291 (AUG) 3:0
Special topics in aerospace engineering 1

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

Kartik Venkatraman

Pre-requisites:
• Instructor's consent is required before registering for this course.
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.

Siddanagouda Kandagal, Duvvuri Subrahmanyam

AE 211 (JAN) 3:0

Mathematical methods for aerospace engineers

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

Joseph Mathew, Arnab Samanta

References:

AE 221 (JAN) 3:0

Aerodynamics

Introduction to aerodynamics, potential flows, conformal mapping and Joukowsk airfoils, Kutta condition, thin airfoil theory, viscous effects and high-lift flows, lifting line theory, vortex lattice method, delta wings, compressibility effect, supersonic flows, unsteady aerodynamics.

Balakrishnan N (CFD), Ramesh O N

References:

Pre-requisites:
• AE 202

AE 222 (JAN) 3:0

Gas Dynamics

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

Joseph Mathew, Gopalan Jagadeesh, Srisha Rao M V

References:
Pre-requisites:
• AE 202

AE 224 (JAN) 3:0
Advanced Fluid Dynamics
Viscosity, stress tensor, Navier-Stokes equations, boundary conditions. Parallel flows in ducts, Stokes/Rayleigh problems, laminar boundary layers, viscous compressible flow. Nature of turbulent flows, Reynolds decomposition and equations, turbulence modelling and computation, free shear and wall-bounded flows, DNS/LES.

Joseph Mathew

References:

Pre-requisites:
• AE 202 or equivalent

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

References:
• Recent Literature.

Pre-requisites:
• AE 202 or equivalent.

AE 229 (JAN) 3:0
Computational Gas Dynamics

Raghurama Rao S V

References:
• Laney, B., Computational Gas Dynamics.
• Toro, E.F., Riemann Solvers and Numerical Methods for Fluid Dynamics.
Pre-requisites:
• AE 202, AE 222, courses in Numerical Analysis/Numerical Methods, and any programming language.

AE 231 (JAN) 3:0
Aerodynamic Testing Facilities and Measurements
Aerodynamic testing in various speed regimes, requirements of aerodynamic testing, design aspects of low speed wind tunnels, flow visualization methods, measurement methods for flow variables. Wind tunnel balances, elements of computer-based instrumentation, measurements and analyses methods. Elements of high speed wind tunnel testing: design aspects to supersonic and hypersonic wind-tunnels, other high speed facilities like shock tube shock tunnels, free piston tunnels, ballistic ranges and low density tunnels, special aspects of instrumentation for high speed flows.

Sourabh Suhas Diwan, Srisha Rao M V, Duvvuri Subrahmanyam

References:

Pre-requisites:
• AE 202 or equivalent

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

References:

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, Dinesh Kumar Harursampath

References:
AE 255 (JAN) 3:0

**Aeroelasticity**

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

**Kartik Venkatraman**

**References:**

**Pre-requisites:**
- A course in solid or fluid mechanics.

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**

**References:**

**Pre-requisites:**
- AE 204 or equivalent.

AE 259 (JAN) 3:0

**Rotary Wing Aeroelasticity**


**Ranjan Ganguli**

**References:**
**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

References:


**AE 271 (JAN) 3:0**

**Guidance Theory and Applications**

Design process, airworthines, safety, environmental issues, requirements, overall configuration and systems, fuselage layout, wing and tail design, mass and balance, power plant selection, landing gear layout, aircraft performance cost estimation, and initial design and sizing

Debasish Ghose, Ashwini Ratnou

References:


Pre-requisites:

- AE 205 or equivalent

**AE 274 (JAN) 3:0**

**Topics in Neural Computation**

Foundation of neural networks: perceptron, multi-layer perceptron, radial basis function network, recurrent neural network; Evolving/online learning algorithms; Deep neural networks: Convolutional neural network, restricted Boltzmann machine; Unsupervised learning; Advanced topics: Reinforcement learning and deep-reinforcement learning; Spiking neural network --- spiking neuron, STDP, rank-order learning, synapse model, SEFRON.

Suresh Sundaram

References:


Pre-requisites:

- Knowledge of algebra, numerical methods, calculus and familiarity with programming in Python and MATLAB.
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.

Kartik Venkatraman

Pre-requisites:
- For registering this course Instructors consent is required

AE 299 (JAN) 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

AE 371 (JAN) 3:0

Applied Nonlinear Control


Radhakant Padhi

References:
- Lecture Notes.

Pre-requisites:
- AE 205 and 272 or equivalent; familiarity with MATLAB

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; 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

References:
• Lecture Notes.

Pre-requisites:
• AE 205 or equivalent and familiarity with MATLAB
Centre for Atmospheric and Oceanic Sciences (CAOS)

CAOS

Preamble:

The Centre for Atmospheric Sciences was established in 1982 and renamed Centre for Atmospheric and Oceanic Sciences in 1996. Known for pioneering work on monsoon physics and variability, its activities now span a broad range of topics in atmosphere, ocean and climate science.

Core Research:

CAOS faculty and students study the monsoons and tropical climate variability, cloud physics and tropical convection, space-time variations of rainfall and extreme rain events, the hydrological cycle, physical oceanography and air-sea interaction, nonlinear climate dynamics, the planetary boundary layer, aerosol physics and chemistry, radiation and climate, large-scale waves and geophysical turbulence, climate change, the carbon cycle and geoengineering. In addition to ocean and climate modelling, data analysis and theoretical work, the Centre has a long tradition of field campaigns to study physical processes from in situ measurements on land and in the atmosphere and ocean.

Current Research:

We highlight a few results to convey a flavour of research at CAOS. Analysis of IMD radar observations have revealed distinct convective cells (“storms”) buried within the widespread cloud cover of the monsoon. Each storm comprises of clusters of cumulonimbus clouds, tens to hundreds of square kilometres in area and lifespan of 30 minutes to 3 hours. Very heavy rainfall is associated with storms, and the outflow from the storms merge in the upper troposphere to produce extensive cloud cover.

The Bay of Bengal plays a fundamental role in the birth of monsoon weather systems. The BoB Boundary Layer Experiment (BoBBLE) was undertaken by India and the United Kingdom in June-July 2016. Physical and biogeochemical observations showed the time evolution of the Sri Lanka dome and the summer monsoon current, and two freshening events when upper ocean salinity decreased, leading to thick barrier layers. These observations, made during a suppressed phase of the monsoon intraseasonal oscillation, captured ocean warming and preconditioning of the atmosphere to convection.

Remote forcings (“teleconnections”) have important implications for seasonal prediction of rainfall over India. It has been shown how these forcings can affect monsoon rainfall. For example, if the previous winter was a La Nina, the rainfall during the current summer over India would decrease slightly. Furthermore, if the present summer is El Nino, last winter’s La Nina increases the probability of drought. These remote effects on the monsoon are manifest slowly, due to the slow propagation of surface pressure anomalies in subtropics as ENSO changes its state with season.
The atmospheric concentration of methane (CH$_4$) has increased by almost 150% since the pre-industrial period, contributing ~20% to the total anthropogenic greenhouse gas radiative forcing. Recent work in the centre has investigated the effectiveness of CH$_4$ in global warming per unit of radiative forcing. Idealized model simulations indicate that the effectiveness of CH$_4$ is nearly ~80% of the role of CO$_2$, and this is related to shortwave absorption bands of CH$_4$.

Black carbon (BC) in the atmosphere does not only exert a warming effect, it also influences Free-Space Optical communication links. Atmospheric warming by an elevated BC-layer at altitude of around 4.5 km enhances atmospheric stability, leading to large reductions in the atmospheric refractive index structure parameter. This alleviates the attenuation of the signal by BC, leading to fewer link outages. The net effect is improvement in wavelength transmission and thus fewer adaptive optics units are required to manage communication systems.

We estimate spatial averages from point observations all the time, but this is not straightforward. With the possibility of missing data, the spatial average is a ratio between random variables. We have extended optimal averaging theory to situations where individual observations might be missing, by deriving convergent series approximations for the bias and variance. We have applied this theory to understand uncertainty in spatial averages of rain-gauge derived precipitation estimates over India, for e.g. Indian Summer Monsoon Rainfall.

In the area of geophysical fluid dynamics, observational data of sea-surface height has been used to understand midlatitude surface ocean dynamics at scales near the local deformation radius, i.e., 200 km to 100 km, where Earth’s rotational effects become important. Calculations of energy and enstrophy fluxes and kinetic energy spectra, from estimated geostrophic currents, compare favourably with corresponding results from a comprehensive Earth system model. These calculations appear to reveal a rotationally dominated portion of a surface oceanic counterpart of the Nastrom-Gage spectrum that describes upper-tropospheric energy and enstrophy cascades in the atmosphere.

In the area of physical oceanography, we have understood the mechanisms of movement and dispersal of river water in the Bay of Bengal with the help of satellite-derived sea surface salinity and surface currents.
AS 203 (AUG) 3:0

Atmospheric Thermodynamics

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

Arindam Chakraborty

References:

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.

Srinivasan J, Satheesh S K

Pre-requisites:
- Scheme of Instruction 2016 Page 183.

AS 205 (AUG) 2:1

Ocean Dynamics

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

Vinayachandran P N

References:

AS 207 (AUG) 3:0

Introduction to Atmospheric Dynamics

Jai Suhas Sukhatme


**AS 216 (AUG) 3:0**

**Introduction to Climate System**

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

Govindasamy Bala

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

**AS 202 (JAN) 3:0**

**Geophysical Fluid Dynamics**


Debasis Sengupta, Jai Suhas Sukhatme

References:

**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

References:

**AS 209 (JAN) 3:0**

**Mathematical Methods in Climate Science**


Venugopal Vuruputur

References:
AS 210 (JAN) 3:0

Numerical methods in atmospheric modeling

Equations used in atmospheric modelling; numerical discretization techniques: finite difference, finite volume, spectral techniques, temporal discretization; modelling of sub-grid scale processes (cumulus parameterization and boundary layer parameterization); algorithms for parallel computation.

Ashwin K Seshadri

References:

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, Satheesh S K

References:

AS 299 (JAN) 0:28

Project

AS 308 (JAN) 2:1

Ocean Modeling

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

Vinayachandran P N

References:
- Chassignet and Vernon J. (ED), Ocean Modeling and Parameterization.
CIVIL ENGINEERING
Syllabus for M Tech Civil Engineering and
M Tech Transportation and Infrastructure Engineering program (2019-20)

M Tech Program in Civil Engineering

**Semester 1 Common to all students**

**Core: 18 Credits**

CE 201 3:0 Basic Geomechanics
CE 202 3:0 Foundation Engineering
CE 203 3:0 Surface Water Hydrology
CE 204 3:0 Solid Mechanics
CE 205 3:0 Finite Element Method
CE 211 3:0 Mathematics for Engineers

a) **To fulfill Major requirement in an Area**, students shall complete minimum 21 course credits (15 core + 6 elective on offer) and 22 Dissertation project credits in the said Area.

b) **For optional Minor in one of the other two Areas**, a student must complete minimum of 12 credits in the said Area.

**Major in Geotechnical Engineering**

**Core: 9 Credits**

CE 206 3:0 Earth and Earth Retaining Structures
CE 207 3:0 Geoenvironmental Engineering
CE 208 3:0 Ground Improvement and Geosynthetics
CE 299 0:22 Dissertation Project

**Major in Structural Engineering**

**Core: 9 Credits**

CE 209 3:0 Mechanics of Structural Concrete
CE 210 3:0 Structural Dynamics
CE 228 3:0 Continuum Plasticity
CE 299 0:22 Dissertation Project

**Major in Water Resources Engineering**

**Core: 12 Credits**

CE 212 3:0 Computational Fluid Dynamics in Water Resources Engineering
CE 213 3:0 Systems Techniques in Water Resources Engineering
CE 214 3:0 Ground Water Hydrology
CE 215 3:0 Stochastic Hydrology
CE 299 0:22 Dissertation Project
Electives in Geotechnical Engineering
CE 220 3:0 Design of Substructures
CE 221 3:0 Earthquake Geotechnical Engineering
CE 222 3:0 Fundamentals of Soil Behaviour
CE 227 3:0 Engineering Seismology
CE 231 3:0 Forensic Geotechnical Engineering

Electives in Structural Engineering
CE 216 3:0 Random Vibration and Reliability Analyses
CE 218 3:0 Fire structural engineering
CE 229 3:0 Non-Destructive Evaluation Methods for Concrete Structures
CE 235 3:0 Optimization Methods
CE 236 3:0 Fracture Mechanics
CE 239 3:0 Stochastic Structural Dynamics
CE 243 3:0 Bridge Engineering
CE 297 3:0 Problems in the Mathematical Theory of Elasticity
CE 298 3:0 Parallel computing in mechanics problems

Electives in Water Resources Engineering
CE 226 3:0 Open-channel Flow
CE 245 3:0 Design of Water Supply and Sewerage Systems
CE 247 3:0 Remote Sensing and GIS for Water Resources Engineering
CE 248 3:0 Regionalization in Hydrology and Water Resources Engineering
CE 249 3:0 Water Quality Modelling
ME 201 3:0 Fluid Mechanics
AS 216 3:0 Introduction to Climate Systems
M Tech Program in Transportation and Infrastructure Engineering

Core: 24 Credits

CE 235 3:0 Optimization Methods
CE 262 3:0 Public Transport System Planning
CE 269 3:0 Traffic Engineering
CE 270 3:0 Travel Demand Modeling
CE 272 3:0 Traffic Network Equilibrium
CE 274 3:0 Sustainable Urban Transportation Planning
CE 211 3:0 Mathematics for Engineers

One 3:0 credit core course from either Geotechnical Engineering/ Structural Engineering/ Water Resources Engineering

CE 299 0:22 Dissertation Project

Electives: 18 Credits of which at least 9 credits should be from among the electives listed below.

CE 202 3:0 Foundation Engineering
CE 208 3:0 Ground Improvement and Geosynthetics
CE 209 3:0 Mechanics of Structural Concrete
CE 247 3:0 Remote Sensing and GIS for Water Resources Engineering
CE 271 3:0 Choice Modeling
CE 273 3:0 Markov Decision Processes
MA 261 3:0 Probability Models
ST 202 3:0 Renewable Energy - Technology, Economics and Environment
ST 203 3:0 Technology and Sustainable Development
MG 221 3:0 Applied Statistics
DS 290 3:0 Modeling and Simulation
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, Introduction to stresses and deformation measures; Mohr-Coulomb failure criteria, soil laboratory tests; Critical state and stress paths. Shear Strength and Stiffness of Sands; Consolidation, shear strength and stiffness of clays

Tejas Gorur Murthy

References:

CE 202 (AUG) 3:0
Foundation Engineering


Anbazhagan P

References:

Pre-requisites:
- B.E/ B.Tech - Soil Mechanics - Course Completion

CE 203 (AUG) 3:0
Surface Water Hydrology

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

Srinivas V V

References:

CE 204 (AUG) 3:0
Solid Mechanics


Narayan K Sundaram

References:
• Malvern L., Introduction to the Mechanics of a Continuous Medium, Prentice Hall, 1969

Pre-requisites:
• No specific prerequisite course, but a good grasp of undergraduate multi-variable calculus, linear algebra and Strength of Materials is highly recommended

CE 205 (AUG) 3:0
Finite Element Method


Chandra Kishen J M

References:

CE 211 (AUG) 3:0
Mathematics for Engineers


Debraj Ghosh, Tarun Rambha

References:
• Probability, Random Variables and Stochastic Processes, A Papoulis and S U Pillai
• Linear Algebra and Its Applications by Gilbert Strang
CE 216 (AUG) 3:0
Random Vibration and Reliability Analyses

Manohar C S

References:

Pre-requisites:
• Background in structural dynamics and theory of probability

CE 218 (AUG) 3:0
Fire structural engineering

Manohar C S

References:
• A H Buchanan, 2002, Structural design for fire safety, Wiley, Chichester.
• B Karlsson, and J Quintiere. 1999, Enclosure fire dynamics. CRC press, Boca Raton

Pre-requisites:
• Basic course in solid mechanics.

CE 220 (AUG) 3:0
Design of Substructures
Design considerations, field tests for bearing capacity and settlement estimates, selection of design parameters. Structural design considerations. Codes of practice. Design of spread footings, combined footings, strap footings, ring footings, rafts, piles and pile caps and piers.

Raghuveer Rao P

References:
• Bowles,J.E. Foundation analysis and design. 5th Edn.,McGraw Hill,1996
• Indian Standard Codes
CE 221 (AUG) 3:0
Earthquake Geotechnical Engineering


Gali Madhavi Latha

References:
• Geotechnical Earthquake Engineering By Steven L. Kramer, Pearson Education, 2003
• Current Literature

CE 226 (AUG) 3:0
Open-channel Flow


Mujumdar P P

References:

CE 231 (AUG) 3:0
Forensic Geotechnical Engineering

Introduction, Definition of a Forensic Engineer, Types of Damage, Planning the Investigation, investigation methodology, Collection of Data, Distress Characterization, Development of Failure, Hypothesis, Diagnostic Tests, Back Analysis, Technical Shortcomings, Legal Issues Reliability Aspects, Observation Method of Performance Evaluation, Case Histories related to settlement of Structures, lateral movement, backfill settlements, causes due to soil types such as collapsible soil, expansive soil, soluble soils, slope Failures and landslides, debris flow, slope softening and creep, trench collapses, dam failures, foundation due to earthquakes, erosion, deterioration, tree roots, groundwater and moisture problems, groundwater problems, retaining failures problems, pavement failures and issues, failures in soil reinforcement and geosynthetics, development of codal provisions and performance based analysis procedures.

Sivakumar Babu G L

References:

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 Crack Propagation; Finite Elements in Fracture Mechanics.

Remalli Vidya Sagar

References:

• David Broek, Elementary Fracture Mechanics, Sijthoff and Noordhoff, The Netherlands.

CE 243 (AUG) 3:0

Bridge Engineering

Bridge types, aesthetics, general design considerations and preliminary design, IRC/ AASHTO design loads, concrete bridge design - reinforced and prestressed girder bridges, steel bridge design Composite bridges, design of bridge bearings, Pier, Abutment and foundation; seismic and wind load analysis, analysis of cable supported bridge systems, bridge inspection and maintenance.

Ananth Ramaswamy

References:

• Barker and Puckett Design of Highway Bridges, John Wiley and Sons 2007

CE 245 (AUG) 3:0

Design of Water Supply and Sewerage Systems


Mohan Kumar M S

References:


CE 247 (AUG) 3:0

Remote Sensing and GIS for Water Resources Engineering


Nagesh Kumar D

References:

CE 249 (AUG) 3:0
Water Quality Modeling

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

Sekhar M

References:

CE 269 (AUG) 3:0
Traffic Engineering


Tarun Rambha

References:
• May, A. D. (1990), Traffic Flow Fundamentals, Prentice Hall, USA.
• Highway Capacity Manual (2010), Transportation Research Board, USA.

CE 270 (AUG) 3:0
Travel Demand Modeling

Individual travel behavior and aggregate-level travel demand analysis; Alternative approaches to modeling travel demand (aggregate, trip-based approaches and disaggregate, activity-based approaches); Econometric methods for modeling travel demand (development, estimation, and application of statistical models for travel behavior analysis); Linear regression for activity and trip generation (specification, interpretation, estimation, hypothesis testing, market segmentation, non-linear specification, tests on assumptions); Mode choice and destination choice using discrete choice methods (introduction to binary logit and multinomial logit models, contrast with gravity methods); Traffic assignment/route choice (network equilibrium, system optimum); Model transferability; Microsimulation for activity-based models; Recent advances.

Abdul Rawoof Pinjari

References:
• F. Koppelman and C.R. Bhat. A Self-Instructing Course in Mode Choice Modeling: Multinomial and Nested Logit Models
CE 273 (AUG) 3:0

Markov Decision Processes

Discrete time Markov chains; Transient and limiting behavior; Finite horizon MDPs; Backward induction; Infinite horizon models; Discounted, average, and total cost MDPs; Value and policy iteration; Linear programming methods; Approximate dynamic programming; Reinforcement learning; Dynamic discrete choice models; Applications to shortest paths, airline ticketing, dynamic pricing, adaptive signal control, and demand estimation.

Tarun Rambha

References:


CE 206 (JAN) 3:0

Earth and Earth Retaining Structures


Jyant Kumar

References:


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

References:


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

References:


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

References:

• 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


Manohar C S

References:

• Meirovich, L., 1984, Elements of vibration analysis, McGraw-Hill, NY
• Clough R W and J Penzien, 1993, Dynamics of structures, McGraw-Hill, NY

CE 212 (JAN) 3:0

Computational Fluid Dynamics in Water Resources Engineering
Governing equations of fluid dynamics, numerical solution of ODEs, Classification of Quasi-Linear PDEs, classification of PDEs, Solution methods for Parabolic, Elliptic and Hyperbolic PDEs and their analysis. Curvilinear co-ordinates and grid generation. Introduction to finite difference, finite volume and finite elements method, Application of CFD to open channel flow, pipe flow, porous media and contaminant transport problems.

Mohan Kumar M S

References:
- Computational Fluid Dynamics: Applications in Environmental Hydraulics, edited by Paul D. Bates, Stuart N. Lane, Robert I. Ferguson, Wiley; 1st edition

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

References:
- Srinivasa Raju, K and Nagesh Kumar, D., Multicriterion Analysis in Engineering and Management, PHI Ltd., New Delhi, 2010.

CE 214 (JAN) 3:0
Ground Water Hydrology


Sekhar M

References:

CE 215 (JAN) 3:0
Stochastic Hydrology

**Mujumdar P P**

References:
- Clarke, R.T., Statistical Models in Hydrology, John Wiley, Chinchester, 1994

**CE 227 (JAN) 3:0**

**Engineering Seismology**


**Anbazhagan P**

References:

**CE 228 (JAN) 3:0**

**Continuum Plasticity**

Brief reviews of finite deformation kinematics and constitutive closure; introduction to rational thermodynamics and formulation of constitutive theories; internal variables; dissipation inequality; physics of yielding; plastic flow and hardening; notion of yield surface; classical models for yielding; plastic flow and hardening; additive and multiplicative splitting of kinematic quantities; solutions of simple BVPs; FEM for small deformation plasticity; yield free plasticity models; linearization and computational schemes; introduction to damage mechanics

**Debasish Roy**

References:
- A S Khan, S Huang, 1995, Continuum Theory of Plasticity, John Wiley, NY

Pre-requisites:
- A graduate level course in solid mechanics or continuum mechanics.

**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 based 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

References:
- C. V. Subramanian (2016) Practical Ultrasonics., Narosa publishers

CE 235 (JAN) 3:0
Optimization Methods

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

Ananth Ramaswamy

References:
- Current Literature.

CE 239 (JAN) 3:0
Stochastic Structural Dynamics


Debasish Roy

References:
- Kloeden, P.E. and Platen, E., Numerical Solutions of Stochastic Differential Equations, Springer

CE 248 (JAN) 3:0
Regionalization in Hydrology and Water Resources Engineering

Srinivas V V

References:

Pre-requisites:
• CE 203

CE 262 (JAN) 3:0
Public Transportation Systems Planning
Modes of public transportation and application of each to urban travel needs; comparison of transit modes and selection of technology for transit service; transit planning, estimating demand in transit planning studies, demand modeling, development of generalized cost, RP & SP data and analysis techniques; functional design and costing of transit routes, models for planning of transit routes, scheduling; management and operations of transit systems; integrated public transport planning; operational, institutional, and physical integration; models for integrated planning; case studies.

Ashish Verma

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

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

References:

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
References:

CE 297 (JAN) 3:0
Problems in the Mathematical Theory of Elasticity


Narayan K Sundaram

References:
- Current and historic literature

Pre-requisites:
- Graduate-level solid mechanics (CE-204 / ME-242 or equivalent) with a grade of B or higher, or instructor consent.

CE 298 (JAN) 3:0
Parallel computing in mechanics problems

Introduction to parallel computing. Parallelization using MPI. Parallel operations on vectors and matrices; linear systems solving and eigenvalue problems. Substructuring and domain decomposition. Parallelization in statistical simulation.

Debraj Ghosh

References:

Pre-requisites:
- Programming experience using one of the languages among C/C++/Fortran. Familiarity with Linux/Unix.

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
### Courses in the Department (2019)

<table>
<thead>
<tr>
<th>August Semester</th>
<th>January Semester</th>
</tr>
</thead>
<tbody>
<tr>
<td>CH 201 3:0 Engineering</td>
<td>CH 205 3:0 Chemical Reaction</td>
</tr>
<tr>
<td>Mathematics</td>
<td>Engineering</td>
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<tr>
<td>CH 202 3:0 Numerical Methods</td>
<td>CH 207 1:0 Applied Statistics &amp;</td>
</tr>
<tr>
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<td>design of Experiments</td>
</tr>
<tr>
<td>CH 203 3:0 Transport Phenomena</td>
<td>CH 232 3:0 Physics of Fluids</td>
</tr>
<tr>
<td>CH 204 3:0 Thermodynamics</td>
<td>CH 234 3:0 Rheology of Complex</td>
</tr>
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<td>Fluids</td>
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<tr>
<td>CH 206 1:0 Seminar</td>
<td>CH 236 3:0 Statistical</td>
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<td>Thermodynamics</td>
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<tr>
<td>CH 235 3:0 Modelling in Chemical Engineering</td>
<td>CH 243 3:0 Mechanics of Particle</td>
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<td></td>
<td>Suspensions</td>
</tr>
<tr>
<td>CH 242 3:0 Special Topics in</td>
<td>CH 245 3:0 Interfacial and Colloidal</td>
</tr>
<tr>
<td>Theoretical Biology</td>
<td>Phenomena</td>
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<td>CH 244 3:0 Treatment of Drinking Water</td>
<td>CH 247 3:0 Introduction to Molecular</td>
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<tr>
<td>CH 248 3:0 Molecular Systems</td>
<td>CH 249 3:0 Structural and Functional</td>
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<tr>
<td>Biology</td>
<td>DNA Nanotechnology</td>
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<tr>
<td>CH 299 0:32 Dissertation</td>
<td></td>
</tr>
<tr>
<td>Project (M Tech)</td>
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</tr>
</tbody>
</table>

The detailed content of the active courses in a given academic year is appended below. Please note that all the courses listed above are not active every year.

The table below shows the department requirements for its various programmes.

<table>
<thead>
<tr>
<th>Programme</th>
<th>Credits</th>
<th>Department Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>M Tech Programme, duration 2 years</td>
<td>64</td>
<td>Course work of 32 credits includes a core of 17 credits (CH 201 to CH 207), and a soft</td>
</tr>
<tr>
<td></td>
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<td>core of 6 credits from the department offerings. The project work is equivalent of 32</td>
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<tr>
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<td>credits.</td>
</tr>
<tr>
<td>Programme</td>
<td>Credits</td>
<td>Requirements</td>
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<td>----------------------------------------------------</td>
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<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>M Tech (Res) Programme</td>
<td>12</td>
<td>CH 201 or CH 202, and a minimum of two from CH 203, CH 204, and CH 205. CH 206 and CH 207 are compulsory. A maximum of 21 credits is permitted.</td>
</tr>
<tr>
<td>PhD Programme, after Bachelor’s degree</td>
<td>24</td>
<td>CH 201 to 207 are compulsory. A maximum of 33 credits is permitted.</td>
</tr>
<tr>
<td>PhD Programme, after Master’s degree</td>
<td>12</td>
<td>CH 201 or CH 202, and a minimum of two from CH 203, 204, and 205. CH 207 is compulsory. A maximum of 21 credits is permitted.</td>
</tr>
</tbody>
</table>
**CH 201 (AUG) 3:0**  
**Engineering Mathematics**


Prabhu R Nott

**References:**

**Pre-requisites:**
- A basic course in Engineering or Applied Mathematics, including linear algebra, ordinary and partial differential equations.  
- UG students must seek approval of instructor prior to registering for the course.

**CH 202 (AUG) 3:0**  
**Numerical Methods**


Bhushan J Toley

**References:**

**CH 203 (AUG) 3:0**  
**Transport Processes**


Kumaran V

**References:**
**CH 204 (AUG) 3:0**

**Thermodynamics**

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

*Sudeep Punnathanam*

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

**CH 206 (AUG) 1:0**

**Seminar Course**

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

*Kesava Rao K*

*Pre-requisites:*
  - Open only to the Students from the Chemical Engineering Department

**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.

*Sanjeev Kumar Gupta*

*References:*
  - Lecture notes

**CH 248 (AUG) 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*

*References:*
CH 205 (JAN) 3:0
Chemical Reaction Engineering


Venugopal S

References:
- Ming, D., Glasser, D., Hildebrandt

CH 207 (JAN) 1:0
Applied statistics and design of experiments

Overview of statistics; sample spaces and events; discrete and continuous random variables and probability distributions; sample mean and variance; point and interval estimates of the sample mean; tests of hypotheses; confidence intervals for the difference in the means of two samples; linear regression; introduction to designed experiments; analysis of variance; factorial experiments

Venugopal S

References:
- Current literature

CH 234 (JAN) 3:0
Rheology of Complex Fluids and Particulate Materials

Introduction to the kinematics and rheology of complex fluids: Polymeric fluids, Suspensions, Pastes, and Granular materials; Flow phenomena in complex fluids: Shear thinning and thickening, Shear bands, Creep; Introduction to principles of rheology; Kinematics: Viscometric flows; Material functions: Rheometry in simple flows; Rheological models: Generalized Newtonian fluid, Models for viscoelasticity, Models for plasticity and viscoplasticity; Applications to simple flow problems.

Prabhu R Nott

References:

CH 245 (JAN) 3:0
Interfacial and Colloidal Phenomena

Interfaces, Young-Laplace and Kelvin equations for curved interfaces; interfacial tension and contact angle, measurement techniques; wetting and spreading; colloids: Intermolecular forces, London-van der Waals attraction, double layer repulsion, zeta potential, DLVO theory of colloidal stability; non-DLVO forces; surfactants; thermodynamics of self-assembly, phase diagrams; electro-kinetic phenomena; electrochemical systems.
Sanjeev Kumar Gupta

References:
• Berg, J. C. An Introduction to Interfaces and colloids, The bridge to nanoscience, World Scientific, 2010
• Lecture notes (book) given by instructor.

CH 247 (JAN) 3:0
Introduction to Molecular Simulations

Introduction to molecular dynamics; conservation laws; integration schemes: verlet, velocity verlet, leap-frog; constraint dynamics; extended Lagrangian dynamics; Thermostats and barostats; introduction to Monte Carlo techniques; Metropolis algorithm; NVT, NPT and GCMC simulations; estimation of pressure, chemical potential, radial distribution function, auto-correlation function, Ewald summation; umbrella sampling; Gibbs Ensemble technique; configuration bias technique, free energy estimation using thermodynamic integration

Ganapathy Ayappa, Sudeep Punnathanam

References:

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.

Venugopal S
Dept of Mechanical Engineering

M Tech Programme
Duration: 2 years
64 credits

Hard Core: 1 credit
ME 297 1:0 Seminar Course

Soft Core: (Any 4 out 5) 12 credits
ME 201 3:0 Fluid Mechanics
ME 228 3:0 Materials & Structure Property Correlations
ME 240 3:0 Dynamics & Control of Mechanical Systems
ME 242 3:0 Solid Mechanics
ME 271 3:0 Thermodynamics

Maths requirement: 3 credits
ME 261 3:0 Engineering Mathematics

OR
Any other equivalent course recommended by the department

Project: 27 Credits
ME 299 0:27 Dissertation Project

Electives: 21 credits
The balance of 21 credits required to make up a minimum of 64 credits to complete the M.Tech Program.
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.

Jaywant H Arakeri, Ratnesh K Shukla

Pre-requisites:
• Kundu, P.K., and Cohen, I.M., Fluid Mechanics

ME 225 (AUG) 1:0
Introduction to Soft Matter
Introductory course on soft matter/complex fluids. A review of preliminaries of continuum mechanics, which are required for dealing with soft matter. General concepts of viscous and elastic deformations and relevant models. Experimental approaches to soft materials such as creep response and stress relaxation.

Aloke Kumar

References:
• Bird, R.B., Armstrong, R.C., Hassager, O., Dynamics of Polymeric Fluids, John Wiley and Sons
• Joseph, D.D, Fluid Dynamics of Viscoelastic Liquids, Springer-Verlag, 1990
• R.C.
• Hassager

ME 228 (AUG) 3:0
Materials and Structure Property Correlations

Satish V Kailas, Koushik Viswanathan

Pre-requisites:
• Raghavan, V., Materials Science and Engineers, Prentice Hall, 1979. Davidge

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.

Ashitava Ghosal, Jayanth G R

References:
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.

Chandrashekhar S Jog

Pre-requisites:
- Sokolnikoff, I.S., Mathematical Theory of Elasticity, Prentice Hall.
- Fung Y C
- Srinath. L. S.
- Advanced Mechanics of Solids
- Tata McGraw Hill.

ME 243 (AUG) 3:0
Continuum Mechanics
Introduction to vectors and tensors, finite strain and deformation-Eulerian and Lagrangian formulations, relative deformation gradient, rate of deformation and spin tensors, compatibility conditions, Cauchy's stress principle, stress tensor, conservation laws for mass, linear and angular momentum, and energy. Entropy and the second law, constitutive laws for solids and fluids, principle of material frame indifference, discussion of isotropy, linearized elasticity, fluid mechanics.

Chandrashekhar S Jog

References:
- Gurtin

ME 250 (AUG) 3:0
Structural Acoustics

Venkata R Sonti

Pre-requisites:
- Consent of Instructor
- Fundamentals of acoustics ME249
- Sound and Structure Interaction by Frank Fahy

ME 255 (AUG) 3:0
Principles of Tribology
Yogendra Simha K R, Bobji M S

Pre-requisites:

ME 259 (AUG) 3:0
Nonlinear Finite Element Methods


Narasimhan R

References:

Pre-requisites:
• ME 257 or equivalent course.

Co-requisites:
• Student should have working knowledge of Fortran programming

ME 260 (AUG) 3:0
Topology Optimization


Ananthasuresh G K

Pre-requisites:
• ME 256. Background in finite element analysis is preferred. Bendsoe, M.P., and Sigmund, O.

ME 261 (AUG) 3:0
Engineering Mathematics

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

Pre-requisites:

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-equilibrium thermodynamics, multi-phase-multi component systems, transport properties; third law

Pramod Kumar, Susmita Dash

Pre-requisites:
- “Fundamentals of Classical Thermodynamics”, by G. Van Wylen, R. Sonntag and C. Borgnakke
- “Fundamentals of Engineering Thermodynamics”, by Moran and Shapiro
- “Advanced Thermodynamics for Engineers” by Kenneth Wark, Fluid Flow: A First Course in Fluid Mechanics

ME 285 (AUG) 3:0
Turbomachine Theory

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

Raghuraman N Govardhan

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

ME 289 (AUG) 3:0
Principles of Solar Thermal Engineering

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

Narasimham G S V L

References:

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.
Susmita Dash

Pre-requisites:
• Faculty Coordinator

ME 244 (JAN) 3:0
Experimental Methods in Microfluidics

Introduction to experimental methods used in microfluidic systems. Fundamentals of flows at the microscale; emphasis on visualization and quantification of fluid flow at the micron-scale. Brownian motion and its quantification. Particle image velocimetry (PIV), micro-particle image velocimetry (µ-PIV) and three-component flow measurement in three dimensions. Measuring displacement at the micron scale; digital image correlation (DIC). Thermometry at the micron-scale; laser induced fluorescence (LIF). Applications to microfluidic, biomicrofluidic and

Aloke Kumar

Pre-requisites:

ME 246 (JAN) 3:0
Introduction to Robotics

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

Ashitava Ghosal

References:

ME 249 (JAN) 3:0
Fundamentals of Acoustics

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

Venkata R Sonti

References:
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  
References:  

ME 253 (JAN) 3:0  
Vibrations of Plates and Shells  
Shell coordinates, infinitesimal distances in curved shells, equations of motion for general shell structures using Hamilton’s principle, specialization to commonly occurring geometries, detailed study of flat plates, rings, cylindrical shells and spherical shells, natural frequencies and modes, Rayleigh-Ritz and Galerkin methods, response to various types of loads (point forces, moments, moving loads), transient and harmonic loads, combination of structures using receptance.  
Venkata R Sonti  
Pre-requisites:  
• a full course in lumped system vibrations, Werner Soedel, Vibrations of plates and shells, S.S. Rao Vibrations of continuous systems

ME 256 (JAN) 3:0  
Variational Methods and Structural Optimization  
Calculus of variations: functionals, normed vector spaces, Gateaux variation, Frechet differential, necessary conditions for an extremum, Euler-Lagrange multiplier theorem, second variations and sufficient conditions. Weak form of differential equations, application of Euler-Lagrange equations for the analytical solution of size optimization problems of bars and beams, topology optimization of trusses and beams applied to stiff structures and compliant mechanisms. Material interpolation methods in design parameterization for topology optimization, optimization formulations for structures and compliant mechanisms involving multiple energy domains and performance criteria. Essential background for Karush-Kuhn-Tucker conditions for multi-variable optimization, numerical optimization algorithms and computer programs for practical implementation of size, shape and topology optimization problems.  
Ananthasuresh G K  
References:  

ME 257 (JAN) 3:0  
Finite Element Methods  
Linear finite elements procedures in solid mechanics, convergence, isoparametric mapping and numerical integration. Application of finite element method to Poisson equation, calculus of variations, weighted residual methods, introduction of constraint equations by Lagrange multipliers and penalty method, solution of linear algebraic equations, finite element programming.
Chandrashekhar S Jog

References:

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

References:

ME 274 (JAN) 3:0
Convective Heat Transfer
Energy equation, laminar external convection, similarity solution, integral method, laminar internal convection, concept of full development heat transfer in developing flow, turbulent forced convection, free convection from vertical surface, Rayleigh-Benard convection.

Saptarshi Basu, Pramod Kumar

Pre-requisites:

ME 282 (JAN) 3:0
Computational Heat Transfer and Fluid Flow

Ratnesh K Shukla

Pre-requisites:

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

Gaurav Tomar, Susmita Dash

References:
• P de Gennes, F Brochard-Wyart and D Quéré, “Capillarity and wetting phenomena”, Springer, 2004

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

References:

ME 288 (JAN) 3:0
Air Conditioning Engineering

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

References:

ME 290 (JAN) 3:0
Mechanics of slender elastic structures

Ramsharan Rangarajan

ME 291 (JAN) 3:0
Analysis of Manufacturing Processes

This course will provide a graduate-level introduction to manufacturing processes, from processing raw stock material to the final finished product. The emphasis will be on performing simple analyses to obtain quantitative estimates for process parameters (e.g., forces, pressures, energy) and product properties.
Processes will be discussed and analysed following a broad classification and accompanied by in-class or lab demonstrations when possible. At the end of the course, the students will undertake a case study, where they will pick a product and make decisions, with relevant analysis, on the manufacturing process for each major sub-component.

Koushik Viswanathan

References:

ME 293 (JAN) 3:0
Fracture Mechanics
Yogendra Simha K R, Narasimhan R

ME 295 (JAN) 3:0
Geometric Modelling for Computer Aided Design

Representation of curves and surfaces-parametric form, Bezier, B. Spline and NURBS, intersection of curves and surfaces, interpolation, topology of surfaces, classification, characterization, elements of graph theory, representation of solids: graph based models and point set models, Euler operators, boundary evaluation, computation of global properties of solids.

Gurumoorthy B, Dibakar Sen

References:

ME 298 (JAN) 3:0
Fluid Turbulence

Stability of fluid flows, transition to turbulence-introduction to turbulence, Reynolds averaged equations, statistical description of turbulence, vorticity dynamics, similarity methods, turbulent shear flows, Rayleigh Benard convention, modeling and numerical methods.

Jaywant H Arakeri

Pre-requisites:

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.
Department of Materials Engineering

The Department of Materials Engineering is dedicated to the advancement of education and research in metallurgy and materials engineering. The research interests of the Department encompass Advanced Materials including nano-and bio-materials, ceramics, polymers, Structure-property relationship in metallic and non-metallic materials in both crystalline and amorphous form and advanced composites, in addition to the core areas like Process Metallurgy, Extractive Metallurgy, Physical Metallurgy and Mechanical behavior of materials. The Department plays a major role in the Advanced Facility for Microscopy and Microanalysis.
MT 202 (AUG) 3:0

Thermodynamics and Kinetics

Classical and statistical thermodynamics, Interstitial and substitutional solid 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.

Abinandanan T A

References:
• C.H.P. Lupis: Chemical Thermodynamics of Materials, Elsevier Science, 1982

MT 203 (AUG) 3:0

Materials Design and Selection

After an overview of microstructures, processing and properties in engineering materials, the students will focus on procedures for materials selection and design. The students will explore materials selection charts, and the course will involve case studies, projects as well as software packages for materials design and selection over a wide range of conditions

Atul H Chokshi

References:
• M.F. Ashby and D. Johnson: Materials and Design (2002).

MT 206 (AUG) 3:0

Texture and Grain Boundary Engineering

Concepts of texture in materials, their representation by pole figure and orientation distribution functions. Texture measurement by different techniques. Origin and development of texture during material processing stages: solidification, deformation, annealing, phase transformation, coating processes, and thin film deposition. Influence of texture on mechanical and physical properties. Texture control in aluminum industry, automotive grade and electrical steels, magnetic and electronic materials. Introduction to grain boundary engineering and its applications.

Satyam Suwas

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: Macrotextrue, Microtexture and Orientation mapping, Gordon and Breach Science Publishers
• F. J. Humphreys and M. Hatherly, Recrystallization and Related Phenomenon, Pergamon Press
• P. E. J. Flewitt, R. K. Wild, Grain Boundaries

MT 209 (AUG) 3:0

Defects in Materials

interaction, dislocation-interface interactions, segregation, etc. Overview of methods for studying defects including computational techniques

Karthikeyan Subramanian

References:

MT 218 (AUG) 3:0
Modeling and Simulation in Materials Engineering

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

Abhik N Choudhury

References:
• David V. Hutton, Fundamentals of Finite Element Analysis

MT 235 (AUG) 3:0
Corrosion Technology

Basic electrochemical principles governing corrosion. Types and mechanisms of corrosion. Advances in corrosion engineering and control. Anodic and Cathodic control-Biocorrosion, mechanisms and microbiological aspects. Corrosion under sub-soil and sea water conditions- Marine biofouling and biocorrosion with respect to industrial conditions. Methods of abatement.

Abinandanan T A, Natarajan K A

References:
• Borenstein: Microbiologically Influenced Corrosion Handbook.

MT 241 (AUG) 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
References:
- 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

MT 245 (AUG) 3:0
Transport Processes in Process Metallurgy
Govind S Gupta

References:

MT 253 (AUG) 3:0
Mechanical Behaviour of Materials
Subodh Kumar

References:

MT 261 (AUG) 3:0
Organic Electronics
Praveen C Ramamurthy

References:
MT 201 (JAN) 3:0
Phase Transformations


Chandan Srivastava

Pre-requisites:
• Basic courses on crystallography, thermodynamics, phase diagrams and diffusion.

MT 208 (JAN) 3:0
Diffusion in Solids

Aloke Paul

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

MT 213 (JAN) 3:0
Electronic Properties of Materials

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

Subho Dasgupta

References:
• S. O. Kasap, Principles of Electronic Materials and Devices.
• S. M. Sze, Semiconductor devices: Physics and Technology.
• D. Jiles, Introduction to the electronic properties of materials

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)

Karthikeyan Subramaniam, Dipankar Banerjee, Abhik N Choudhury
MT 243 (JAN) 0:2
Laboratory Experiments in Materials Engineering
Experiments in Metallographic techniques, heat treatment, diffraction mineral beneficiation, chemical and process metallurgy, and mechanical metallurgy.
Rajeev Ranjan

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

References:

MT 250 (JAN) 3:0
Introduction to Materials Science and Engineering
Subodh Kumar

MT 252 (JAN) 3:0
Science of Materials Processing
Satish V Kailas, Satyam Suwas

References:
• W.A. Backofen: Deformation processing: Addition Wesley.
• R.W. Cahn and P. Haasan (Editors): Processing of Metals and Alloys: Materials Science and Technology series, Wiley VCH

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

References:

MT 256 (JAN) 3:0
Fracture

Vikram Jayaram

References:

MT 258 (JAN) 3:0
Mechanical Behavior of Thin Films
Short description of various thin film deposition techniques; Origin of residual stresses; Determination of stress state in thin films deposited on substrate; Stress relaxation processes, including hillocking and whiskering, grain boundary sliding, and interface governed phenomenon, such as dewetting, buckling, interfacial fracture, interfacial sliding, etc.; Size effects; Mechanical testing of thin films, including nanoindentation.

Praveen Kumar

References:

MT 262 (JAN) 3:0
Concepts in Polymer Blends and Nanocomposites
Suryasarathi Bose

References:

MT 271 (JAN) 3:0

Introduction to Biomaterials Science and Engineering

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

Kaushik Chatterjee

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

MT 299 (JAN) 0:32

Dissertation Project

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

Rajeev Ranjan

MT 220 (MAY) 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)

Karthikeyan Subramanian, Dipankar Banerjee, Abhik N Choudhury

MT 271 (MAY) 3:0

Introduction to Biomaterials Science and Engineering

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

Kaushik Chatterjee

References:
- Ratner et al: Biomaterials science: An introduction to materials in medicine, Lecture notes, Literature
Centre for Product Design and Manufacturing

Centre for Product Design and Manufacturing (CPDM), established in 1998, is the design and manufacturing face of IISc, and is among the most research and technology intensive design and manufacturing schools in India.

CPDM is among very few schools in India that train students in developing and making systemically complex, technologically intensive, and socially impactful solutions that are functional, aesthetic, usable and sustainable. It is among the top design schools in the world that specialise in training development of hardware products and manufacturing systems.

CPDM pursues excellence in teaching, research and industry interaction in the areas of design and manufacturing. The two-year professional Masters MDes programme (in Product Design and Engineering) has been the flagship programme of the Centre for over two decades. From August 2019, CPDM initiated, along with twelve partnering departments at IISc, an MTech in Smart Manufacturing.

CPDM has two active research programmes. One is in advanced design and engineering, spanning Design Theory & Methodology, Product Lifecycle Management, Human Factors in Design, User Interface Design, Vehicle Design, Technology Integration, Sustainability etc., with major applications in Automotive, Aerospace and Biomedical sectors. The other is an interdisciplinary programme in advanced manufacturing, with the following research areas (see details in the departmental webpage on research programmes): new materials and processes, digital manufacturing, manufacturing supply chains, sustainable manufacturing, Industry 4.0, controls, autonomous systems and robotics, and policy and entrepreneurship in manufacturing.

VISION

Pursue excellence in education, research and practice in the areas of design and manufacturing so as to support development of systemically-complex, technologically-intensive and socially-impactful solutions that are functional, aesthetic, usable and sustainable.

MISSION

Develop professionals in designing products and manufacturing systems that are functional, aesthetic, usable and sustainable; Create leaders who can strengthen existing practice and develop new practice in the areas of design and manufacturing; Develop products and manufacturing systems that can significantly impact the society; Develop knowledge, including methods and tools, to inform and empower practice and education of design and manufacturing.

SALIENT POINTS ABOUT CPDM

1. Pursue excellence in education, research and industrial interaction in design and manufacturing.

2. 2-Year M.Des. programme to train students with undergraduate degrees in engineering or architecture to conceptualize and engineer products to satisfy societal needs considering
functional, aesthetic, ergonomic, materials, manufacturing, cost, sustainability and marketing aspects.

3. 2-year M.Tech. programme to train students, with undergraduate degrees in engineering, in the areas of smart manufacturing, with exposure to design, materials, processes, digital manufacturing, sensors and mechatronics, AI and analytics, and in operations, supply chains and entrepreneurship.

4. Research programme in advanced product design and engineering (MTech by Research and PhD) in a variety of research areas, to develop new knowledge as theories, methods or tools for better design and associated engineering.

5. Research programme in advanced manufacturing (MTech by Research and PhD) in a variety of research areas, to develop new knowledge as materials, processes, systems, methods or tools for (better) manufacturing.
### M Des Programme
**Product Design and Engineering**
Duration 2 years

**Core Courses:** 36 credits to be completed from the following pool of courses

<table>
<thead>
<tr>
<th>CourseCode</th>
<th>Credits</th>
<th>CourseName</th>
</tr>
</thead>
<tbody>
<tr>
<td>PD 201</td>
<td>2:1</td>
<td>Elements of Design</td>
</tr>
<tr>
<td>PD 202</td>
<td>2:1</td>
<td>Elements of Solid and Fluid Mechanics</td>
</tr>
<tr>
<td>PD 203</td>
<td>2:1</td>
<td>Creative Engineering Design</td>
</tr>
<tr>
<td>PD 205</td>
<td>2:1</td>
<td>Materials, Manufacturing and Design</td>
</tr>
<tr>
<td>PD 207</td>
<td>1:2</td>
<td>Product Visualization, Communication and Present</td>
</tr>
<tr>
<td>PD 209</td>
<td>2:1</td>
<td>New Product Development: Concepts and Tools</td>
</tr>
<tr>
<td>PD 211</td>
<td>2:1</td>
<td>Product Design</td>
</tr>
<tr>
<td>PD 212</td>
<td>2:1</td>
<td>Computer Aided Design</td>
</tr>
<tr>
<td>PD 215</td>
<td>2:1</td>
<td>Mechatronics</td>
</tr>
<tr>
<td>PD 216</td>
<td>2:1</td>
<td>Design of Automotive Systems</td>
</tr>
<tr>
<td>PD 217</td>
<td>2:1</td>
<td>CAE in Product Design</td>
</tr>
<tr>
<td>PD 218</td>
<td>2:1</td>
<td>New Product Development: Strategy and Practice</td>
</tr>
<tr>
<td>PD 221</td>
<td>2:1</td>
<td>Methodology for Design Research</td>
</tr>
<tr>
<td>PD 229</td>
<td>0:3</td>
<td>Computer Aided Product Design</td>
</tr>
<tr>
<td>PD 231</td>
<td>2:1</td>
<td>Applied Ergonomics</td>
</tr>
<tr>
<td>PD 232</td>
<td>2:1</td>
<td>Human Computer Interaction</td>
</tr>
<tr>
<td>PD 233</td>
<td>2:1</td>
<td>Design of Biomedical Devices and Systems</td>
</tr>
<tr>
<td>PD 234</td>
<td>2:1</td>
<td>Intelligent User Interface</td>
</tr>
<tr>
<td>PD 235</td>
<td>2:1</td>
<td>Mechanism Design</td>
</tr>
<tr>
<td>PD 236</td>
<td>2:1</td>
<td>Embodiment Design</td>
</tr>
<tr>
<td>PD 239</td>
<td>0:3</td>
<td>Design and Society</td>
</tr>
</tbody>
</table>

**Project:** 16 Credits. This is mandatory for all

<table>
<thead>
<tr>
<th>CourseCode</th>
<th>Credits</th>
<th>CourseName</th>
</tr>
</thead>
<tbody>
<tr>
<td>PD 299</td>
<td>0:16</td>
<td>Dissertation Project</td>
</tr>
</tbody>
</table>

**Electives:** The balance of credits to make up a minimum of 64 credits required to complete the programme may be chosen as electives from within or outside the department, with the approval of the DCC/Faculty Advisor.
# M Tech Programme
## Smart Manufacturing
### Duration 2 years

**Hardcore Courses:** The following courses to be completed by all students (22 Credits)

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Credits</th>
<th>Course Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>MN 201</td>
<td>3:0</td>
<td>Materials and Processes</td>
</tr>
<tr>
<td>MN 202</td>
<td>3:0</td>
<td>Digital Manufacturing</td>
</tr>
<tr>
<td>IN 221</td>
<td>3:0</td>
<td>Sensors and Transducers</td>
</tr>
<tr>
<td>PD 203</td>
<td>2:1</td>
<td>Creative Engineering Design</td>
</tr>
<tr>
<td>EO 238</td>
<td>3:1</td>
<td>Intelligent Agents</td>
</tr>
<tr>
<td>MG 261</td>
<td>3:0</td>
<td>Operations Management</td>
</tr>
<tr>
<td>MN 205</td>
<td>0:3</td>
<td>Maker's Projects</td>
</tr>
</tbody>
</table>

**Softcore Courses:** Min. 12 credits by taking 6 credits from each of the two baskets of courses to be completed by all students

**Basket 1:** Design, Materials, Manufacturing (at least 6 credits)

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Credits</th>
<th>Course Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>MN 203</td>
<td>3:0</td>
<td>Design for Additive Manufacturing</td>
</tr>
<tr>
<td>MN 204</td>
<td>3:0</td>
<td>Human Machine Interfaces for Manufacturing</td>
</tr>
<tr>
<td>ME 291</td>
<td>2:1</td>
<td>Analysis of Manufacturing Processes</td>
</tr>
<tr>
<td>ME 246</td>
<td>2:1</td>
<td>Introduction to Robotics</td>
</tr>
<tr>
<td>MT 252</td>
<td>2:1</td>
<td>Science of Materials Processing</td>
</tr>
</tbody>
</table>

**Basket 2:** Sensors, Systems, Analytics (at least 6 credits)

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Credits</th>
<th>Course Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>EO 259</td>
<td>3:1</td>
<td>Data Analytics</td>
</tr>
<tr>
<td>E3 257</td>
<td>2:1</td>
<td>Embedded System Design</td>
</tr>
<tr>
<td>P3 258</td>
<td>2:1</td>
<td>Design for Internet of Things</td>
</tr>
<tr>
<td>E0 268</td>
<td>3:1</td>
<td>Practical Data Science</td>
</tr>
<tr>
<td>PD 215</td>
<td>2:1</td>
<td>Mechatronics</td>
</tr>
<tr>
<td>MG 223</td>
<td>3:0</td>
<td>Applied Operations Research</td>
</tr>
</tbody>
</table>

**Project:** 28 Credits. This is mandatory for all

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Credits</th>
<th>Course Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>MN 208</td>
<td>0:28</td>
<td>Dissertation Project</td>
</tr>
</tbody>
</table>

**Electives:** The balance of credits to make up a minimum of 64 credits required to complete the programme may be chosen as electives from within or outside the department, with the approval of the DCC/Faculty Advisor.
**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.

Atul H Chokshi, Satish V Kailas, Satyam Suwas, Koushik Viswanathan

References:  

**MN 202 (AUG) 3:0**  
**Digital Manufacturing**

Ashitava Ghosal, Gurumoorthy B, Dibakar Sen

Pre-requisites:  
- Undergraduate-level mathematics, exposure to manufacturing processes, familiarity with CAD and computational tools such as SolidWorks, Matlab.

**PD 201 (AUG) 2:1**  
**Elements of Design**

Shivakumar N D

References:  
- Young, F.M., Visual Studies, Prentice-Hall, USA.  
- Evans, P., and Thomas, M., Exploring the Elements of Design, Thomson, USA.

**PD 202 (AUG) 2:1**  
**Elements of Solid and Fluid Mechanics**
Analysis of stress and strain, failure criteria, dynamics and vibrations. Control of engineering systems, elements of fluid mechanics drag and losses, thermal analysis, problems in structural and thermal design.

Jaywant H Arakeri, Gurumoorthy B

References:  
- Shigley, J.E., Mechanical Engineering Design, McGraw Hill.  
- White, F.M., Fluid Mechanics, Tata McGraw Hill.  
PD 203 (AUG) 2:1
Creative Engineering Design

Amaresh Chakrabarti

References:

PD 205 (AUG) 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.

Satish V Kailas

References:

PD 207 (AUG) 1:2
Product Visualization, Communication and Presentation
Object drawing fundamentals, theory of perspectives, exploded views, sectional views. Fundamentals of lighting, idea representation and communication methods and pitfalls. Materials, tools and techniques of representation in various media like pencil, ink, colour etc. Rendering techniques, air brush illustration. Idea documentation. Fundamentals of photography, video-graphy and digital media. Dark room techniques. Studio assignments in all the above topics. Mock-up modeling and simulation in various materials

Shivakumar N D

References:

PD 209 (AUG) 2:1
New Product Development: Concepts and Tools
Technology-based products, business context, front-end of innovation, opportunity identification, target markets, integrated teams, product features, differentiation from competition, business cases, product architecture, designing and prototyping products, planning for manufacturing capabilities, marketing and sales programs

Gurumoorthy B
References:

PD 217 (AUG) 2:1

CAE in Product Design

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

Anindya Deb

References:

PD 229 (AUG) 0:3

Computer Aided Product Design

Project in re-engineering a product using computer tools for reverse engineering geometry and intent, design evaluation, modification and prototyping.

Ashitava Ghosal, Gurumoorthy B

PD 231 (AUG) 2:1

Applied Ergonomics

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

Dibakar Sen, Rina Maiti

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

PD 232 (AUG) 2:1

Human Computer Interaction

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

Pradipta Biswas

References:
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 unmet needs in the healthcare technologies and systems.

Manish Arora

References:

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-requisites:
• Undergraduate-level mathematics, familiarity with CAD and computational tools such as SolidWorks, Rhino and Matlab.

MN 204 (JAN) 3:0
Human Machine Interaction for Manufacturing
Dibakar Sen, Pradipta Biswas

**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

**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.

**Shivakumar N D**

**References:**
- Ulrich, K.T., and Eppinger, S.D., Product Design and Development, Tata McGraw Hill, India

**PD 212 (JAN) 2:1**

**Computer Aided 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.

**Gurumoorthy B**

**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**

**References:**
Design of Automotive Systems

Classification of automotive systems, interfacing of marketing, design and manufacturing, converting customer's needs into technical targets, vehicle design 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, and FMEA. 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

References:
- Schwaller, A.E., Motor Automotive Technology, Third Edn, Delman Publishers

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

References:
- Michael McGrath, Product Strategy for High Technology Companies, 2nd Edition
- Clayton Christensen, The Innovator's Dilemma, 2016 edition

Pre-requisites:

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, Pradipta Biswas

References:
- Current Literature including papers from Proceedings of the International Conference in Engineering Design, Prague, 1995

Intelligent User Interface

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

References:

PD 235 (JAN) 2:1
Mechanism Design

Dibakar Sen

References:

PD 236 (JAN) 2:1
Embodiment Design
Embodiment methodology, basic components and interfaces, design for performance including strength, usability, maintenance and reliability, Design for manufacturing, assembly, packaging, distribution, services, cost and environmental impact. Dimensioning, tolerance and standards

Gurumoorthy B, Satish V Kailas, Dibakar Sen, Amaresh Chakrabarti

References:

PD 299 (JAN) 0:16
Dissertation Project
Spread over 15 months, commencing immediately after the second semester. It involves complete design and prototype fabrication with full documentation.

Dibakar Sen
Centre for Sustainable Technologies

ST 202 (AUG) 3:0
Energy Systems and Sustainability
Basics of energy resources and systems, renewable energy technologies, climate change and sustainability, climate change mitigation options and low carbon future, energy technologies, economics, policies and programmes. Case studies on renewable energy projects

Dasappa S, Balachandra P

References:
- M. M. El-Wakil, Power Plant Technology, McGraw Hill. 1984

ST 204 (AUG) 1:1
Sustainable Energy and Environment lab
Energy conversion technologies, building comfort studies, water quality, building technologies

Venkatarama Reddy B V, Dasappa S, Monto Mani

Pre-requisites:
- Current literature.

ST 210 (AUG) 3:1
Principles and Applications of GIS and Remote Sensing
Key concepts and principles of remote sensing, GIS and digital image processing. Tools to address environmental problems. Roles of professionals in managing environment in their respective areas.

Ramachandra TV

References:

Pre-requisites:
- NA

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.

Dasappa S, Lakshminarayana Rao M P

References:
• Douglas C. Montgomery, Design and Analysis of Experiments (2012), John Wiley and Sons, Inc.

ST 206 (JAN) 2:1
Environmental and Natural Resources Management


Ramachandra TV

References:

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

References:
• Dixon S.L and Hall C.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 Thermodynamics,Butterworths,1958,
• Baije O.E,Turbo Machines-A guide to Design,Selection and Theory,John Willey & Sons 1981
Centre for Earth Sciences

M Tech Programme in Earth Science

Duration: 2 years: 64 Credits

Hard Core: 24 Credits (All courses are mandatory)

ES 201 2:1 Introduction to Earth System Science
ES 202 3:0 Geodynamics
ES 203 2:1 Introduction to Petrology
ES 204 3:0 Origin and Evolution of Earth
ES 205 3:0 Mathematics for Geophysicists
ES 206 3:0 Topics in Geophysics
ES 207 0:3 Earth Science Laboratories
ES 215 3:0 Introduction to Chemical Oceanography

Project: 25 Credits

Electives: 15 Credits of which at least 9 credits must be from among the group electives listed below.

ES 208 3:0 Mantle Convection
ES 209 3:0 Biogeochemistry
ES 210 3:0 Tectonics and Crustal Evolution
ES 211 3:0 Applied Petrology
ES 212 3:0 Fluid dynamics of planetary interiors
ES 213 3:0 Isotope Geochemistry
ES 214 3:0 Topics on stratigraphy and geochronology
CE 247N 3:0 Remote Sensing and GIS for Water Resources & Environmental Engineering
ES 201 (AUG) 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

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.,

ES 202 (AUG) 3:0

Geodynamics

Introduction to processes shaping the earth; developing chronological constraints. Reference frames and map projections, shape of the earth, Earth’s gravity field, geodesy, isostasy. Earth’s magnetic field, paleomagnetism, geomagnetic reversals. Plate tectonics, evolution of landforms and global seismicity. Earthquake types and quantification, interpreting seismograms, seismic waves and earth’s interior, earthquake source characterization, earthquake and faulting processes; types of faults and relation to stress fields, moment tensors and earthquake focal mechanisms. Effects of earthquakes, earthquakes in Indian context, Structure of the Earth’s interior- density, seismic velocity, pressure and temperature. Lab and field components: Handling earthquake recorders and data acquisition, Seismic Analysis Code and GMT for analyzing and representing global seismicity data.

Kusala Rajendran

References:

ES 203 (AUG) 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

References:
ES 204 (AUG) 3:0

Origin and Evolution of the Earth

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

Ramananda Chakrabarti

References:
- A. P. Dickin, Radiogenic Isotope Geology, Cambridge University Press, 1995;

ES 205 (AUG) 3:0

Mathematics for Geophysicists


Binod Sreenivasan

References:
- Panton, R.L., Incompressible flows, John Wiley & Sons, 2006
- Lecture notes

ES 208 (AUG) 3:0

Mantle Convection

Plate tectonics and mantle convection, Constraining mantle flow from seismic tomography, Maxwell viscoelastic material, Spherical harmonics, Mantle viscosity, Creep mechanisms, Governing equations, Constraints of mantle flow modeling: geoid and dynamic topography, Thermal evolution of the Earth, Convection in other planets.

Attreyee Ghosh

References:
- Schubert, G., Turcotte, D., and Olson, P., Mantle convection in the earth and planets, Cambridge University Press, 2001

ES 216 (AUG) 3:0

Advanced Chemical Oceanography

This is a course designed to delve in to the application of chemical oceanography, especially that of
isotope tracers, to understand the long-term evolution of seawater and climate. The topics covered in the course will broadly include the: (1) the long-term evolution of seawater chemistry from the perspective of strontium, magnesium, osmium, and lithium isotopes; (2) changes in magnesium to calcium ratio of seawater over time; (3) boron isotopes and their application in pH reconstruction; (4) seawater carbonate chemistry – what controls the pH and alkalinity of seawater; (5) proxies and their application in paleoceanography.

Sambuddha Misra

References:
- Tracers in the Sea – Broecker and Peng, LDEO Press, 1983

ES 401 (AUG) 3:0
Natural Hazards and Their Mitigation
Kusala Rajendran

References:
- C.M.R.
- The solid earth: An Introduction to Global Geophysics
- Cambridge University Press
- 2005.

ES 213 (JAN) 3:0
Isotope Geochemistry

Ramananda Chakrabarti

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

ES 214 (MAY) 3:0
Topics in stratigraphy and geochronology

Prosenjit Ghosh, Sajeev Krishnan

References:
Division of Interdisciplinary Research

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, Centre for Sustainable Transportation and Urban Planning, Department of Management Studies, Robert Bosch Centre for Cyber Physical Systems and Supercomputer Education and Research Centre. 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 code.

BE  Biosystems Science & Engineering
CP  Cyber Physics
ER  Energy Research
DS  Computational and Data Sciences
MG  Management Studies
MS  Interdisciplinary Mathematical Sciences
NE  Nano Science and Engineering
UP  Infrastructure, Sustainable Transportation and Urban Planning

The first two digits of the course number have the departmental code as the prefix. All 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. Department of Civil Engg and CiSTUP jointly offer an M Tech Programme in Transportation Engineering. Department of Management Studies offers a Master of Management. 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. G Rangarajan
Chair
Division of Interdisciplinary Research
INTERDISCIPLINARY PROGRAM - BioSystems Science and Engg

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

Core Courses: 9 Credits

BE 203 0:1 Bioengineering practicum 1
BE 204 0:1 Bioengineering practicum 2
BE 207 3:0 Mathematical Methods for Bioengineers
BE 213 2:0 Fundamentals of Bioengineering 1
BE 214 2:0 Fundamentals of Bioengineering 2

Soft core (for students from engineering background who have not taken Biology after school)

BE 206 3:0 Biology for Engineers

Electives offered by department

BE 209 1:0 Digital Epidemiology
BE 210 3:0 Drug Delivery
BE 211 3:0 Cell Mechanics
BE 212 1:0 Research Communications
BE 203 (AUG) 0:1
Bioengineering Practicum 1

Bioengineering Practicum 1 is a compulsory course for all BSSE PhD Students in their first semester of their PhD programme. It is not open for students from other departments. The course provides bioengineering laboratory experience to enable the student to do practical work on a particular field of specialization by working in the laboratories of the thesis advisers. The student is expected to learn the experimental techniques and practical methods pertaining to the research topic undertaken. The evaluation will be based on oral presentation to the BSSE faculty. In this course, the students are expected to work in the laboratory of the adviser(s) and learn the computational and/or experimental techniques required in their research. Generally, the adviser(s) and the student have a general research topic in mind and use that to decide the techniques to be learnt. The purpose of this course is to enable the student to get familiar with the research topic and take the first steps in beginning thesis research. The students are advised to take the initiative to thoroughly understand all the related material of each and every technique they are supposed to learn.

Ananthasuresh G K, Rachit Agarwal

BE 204 (AUG) 0:2
Bioengineering Practicum 2

Bioengineering Practicum 2 is a compulsory course for all BSSE PhD Students in their first semester of their PhD programme. It is not open for students from other departments. The course provides bioengineering laboratory experience to enable the student to do practical work on a particular field of specialization by working in the laboratories of the thesis advisers. The student is expected to learn the experimental techniques and practical methods pertaining to the research topic undertaken. The evaluation will be based on oral presentation to the BSSE faculty. In this course, the students are expected to work in the laboratory of the adviser(s) and learn the computational and/or experimental techniques required in their research. Generally, the adviser(s) and the student have a general research topic in mind and use that to decide the techniques to be learnt. The purpose of this course is to enable the student to get familiar with the research topic and take the first steps in beginning thesis research. The students are advised to take the initiative to thoroughly understand all the related material of each and every technique they are supposed to learn.

Ananthasuresh G K, Rachit Agarwal

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.

Siddharth Jhunjhunwala, Vaishnavi Ananthanarayanan

References:
Digital Epidemiology

Epidemiology is the study of health and disease in populations. Google’s Flu Trends, Flowminder, Healthmap, Biodiaspora are several examples of digital epidemiology already in play. Engineer systems that are built from and depend upon, the seamless integration of computational algorithms and physical components is how National Science Foundation defines the field of cyber physical systems (CPS). Digital Epidemiology can be viewed as a health care application of CPS. The foundations of CPS includes a focus on the modeling of dynamic systems with attention to integrating computing, communication and control in uncertain and heterogeneous environments. Modeling paradigms include linear and non-linear, stochastic, discrete-event and hybrid models that are analyzed by methods of optimization, probability theory and dynamic programming. The purpose of this course is to introduce this emerging discipline of digital epidemiology to students at IISc. This offering of the course will be limited to a class size of 20 students.

Ananthasuresh G K

References:
- Epidemiology, A Very Short Introduction, Rodolfo Saracci, Oxford University Press
- Statistical models in Epidemiology, D. Clayton and M. Hills, Oxford University Press

Pre-requisites:
- The only prerequisite for this course is a reasonable preparation in computational mathematics

Drug Delivery: Principles and Applications

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 strategies for various drug delivery routes; Drug-delivery systems: polymer-drug conjugates, matrix-based systems, reservoir and erodible systems; Responsive and targeted delivery systems; Nanotoxicology and Translational regulatory pathways. Students will also be asked to work on a group-project to propose a drug-delivery application for an existing medical need.

Rachit Agarwal

References:
- Drug Delivery: Fundamentals and Applications, Anya M. Hillery and Kinam Park

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, including measurement of cell mechanics using experimental techniques such as micropipette 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, biomembranes (bilayers, micelles, vesicle formation), cell-cell and cell-matrix interactions, micropipette aspiration, single particle tracking, atomic force microscopy, applications of cell mechanics viz. cell division, migration, morphogenesis, cancer metastasis.
Vaishnavi Ananthanarayanan

References:

Pre-requisites:
- Undergraduate level introduction to Biology
- Undergraduate level introduction to Biology

BE 213 (AUG) 2:0
Fundamentals of Bioengineering 1

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

Bhushan J Toley, Mohit Kumar Jolly

BE 203 (JAN) 0:1
Bioengineering Practicum 1
Rachit Agarwal

BE 204 (JAN) 0:2
Bioengineering Practicum 2
Rachit Agarwal

BE 207 (JAN) 3:0
Mathematical Methods for Bioengineers
Narendra M Dixit

BE 211 (JAN) 3:0
Cell Mechanics
Vaishnavi Ananthanarayanan
BE 212 (JAN) 1:0
Research Communication

The course aims to help you sharpen the communication skills required for a researcher.

Karthik Ramaswamy

References:

BE 214 (JAN) 2:0
Fundamentals of Bioengineering 2

This course covers essentials of biomaterials and 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. Biomaterials: Basics of polymer science, polymeric materials in the body; non-polymeric implantable materials; biological responses to implants; an introduction to drug delivery systems; principles of tissue engineering. Biomechanics: Rigid-body mechanics in the context of motion of limbs and locomotion; elastic-body mechanics of living matter; stress, strain, constitutive relationships, and balance laws; introduction to viscoelasticity; a brief overview of mechanics of muscles.

Ananthasuresh G K, Siddharth Jhunjhunwala

References:
• A Textbook of Biomechanics, S. Pal, Viva Books, New Delhi, India, 2009
• An Introduction to Biomechanics, J. D. Humphrey and S. L. O'Rourke, Springer, 2015
• Muscles, Reflexes, and Locomotion, Princeton University Press, Princeton, NJ, USA, 1984
INTERDISCIPLINARY PROGRAM - ENERGY

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.

Dasappa S, Pradip Dutta, Praveen C Ramamurthy

ER 203 (AUG) 3:1
Renewable Energy sources, Grid Integration and Distribution

Overview of primary and renewable energy sources installed capacity and projected growth. Device physics: Crystal structure, Energy band diagram, Charge carriers, Heterojunctions, Diode characteristics. Photovoltaic device structures, Device fabrication techniques, PV characterization techniques, Reliability and end of life analysis. Introduction to wind energy and micro-hydro, power -speed characteristics, operating point, sub-synchronous and super-synchronous operation of alternators, DFIG, integration to the grid. MPPT for Renewable sources, battery charging, estimation and sizing of PV system for various applications Recent advances in power transmission, Distribution, Components of HV transmission systems, Insulation coordination, Comparison of Air Insulated, Hybrid and Gas Insulated Substations, Earthing and safety measures, electric and magnetic fields. Laboratory experiments 1. Study of the voltage and current of the solar cells 2. Study of the voltage and current in series and parallel combinations 3. Study of both current and voltage characteristics and power curve to find the maximum power point and efficiency of solar cell 4. To calculate the efficiency of solar cell 5. Study of observation of single axis solar tracking in time mode 6. Study of observations of single axis solar tracking in auto mode 7. Study of the operation of dual axis solar tracking system in manual mode 8. To show the effect of variation in tilt angle on PV module power 9. To demonstrate the effect of shading on module output power 10. To demonstrate the working of a diode as a Bypass diode and blocking diode 11. Technical visit to Solar field & substation

Umanand L, Subba Reddy Basappa, Praveen C Ramamurthy

References:
• Semiconductor Physics and Devices Basic Principles Donald A. Neamen, McGraw Hill publications. IEEE transactions, Photovoltaic specialist conferences etc. Recent Journals and conference publications

ER 204 (AUG) 3:0
Energy and Environment

Basic Thermodynamics and Thermochemistry, Chemical equilibrium, Chemical kinetics, Pollutant formation in energy generation, Atmospheric Smog formation, Pollutant abatement techniques, Clean Coal technologies, Measurements and analysis of Emissions from devices using solid, liquid and gaseous fuels and their impact on climate and other aspects of the environment, Aerosols, Black carbon, Aerosol measurement techniques, Effect of aerosols on surface reaching solar radiation.

Dasappa S, Ravikrishna, R. V., Satheesh S K
References:
• Borman, G.L. and Ragland, K.W., Combustion Engineering, McGraw-Hill International Editions, Mechanical engineering series,
• Papers from Current literature

ER 206 (AUG) 3:0

Transport Phenomena in Energy Systems


Saptarshi Basu, Pramod Kumar
Computational and Data Sciences

M Tech Programme
Duration: 2 years
64 Credits

Course structure:

Hard Core : 14 credits (incl. Research Methods: 1 credit soft skills course)
Soft Core : 10 credits minimum (at least three courses)
Dissertation : 28 credits
Electives : 12 credits (Students may credit CDS electives/soft core or other department courses)

Total: 64 credits

Hard Core Courses (14 credits): All are compulsory
  
  DS 221 AUG 3:1 Introduction to Scalable Systems
  DS 284 AUG 2:1 Numerical Linear Algebra
  DS 288 AUG 3:0 Numerical Methods
  DS 294 JAN 3:0 Data Analysis and Visualization
  DS 200 AUG 0:1 Research Methods – SOFT SKILLS COURSE

Soft Core Courses (10 credits): Minimum three courses out of six below

  DS 201 AUG 2:0 Bioinformatics
  DS 211 AUG 3:0 Numerical Optimization
  DS 256 JAN 3:1 Scalable Systems for Data Science
  DS 289 JAN 3:1 Numerical Solution of Differential Equations
  DS 290 AUG 3:0 Modelling and Simulation
  DS 295 JAN 3:1 Parallel Programming

Dissertation Project: DS 299 0:28 (0:4 Summer; 0:8 AUG; 0:16 JAN)

The balance of credits to make up the minimum of 64 required for completing the programme (all at 200 level or higher).
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.

Phaneendra Kumar Yalavarthy

Pre-requisites:
• Consent from Advisor, Basic knowledge of English, Basic comprehension skills

DS 201 (AUG) 2:0
Bioinformatics
Unix utilities, overview of various biological databases (Protein Data Bank, structural classification of proteins, genome database and Cambridge structural database for small molecules), introduction to protein structures, introduction to how to solve macromolecular structure using various biophysical methods, protein structure analysis, visualization of biological macro molecules, data mining techniques using protein sequences and structures, short sequence alignments, multiple sequence alignments, genome alignments, phylogenetic analysis, genome context-based methods, RNA and transcriptome analysis, mass spectrometry applications in proteome and metabolome analysis, molecular modeling, protein docking and dynamics simulation. Algorithms, scaling challenges and order of computing in big biological data.

Sekar K, Debnath Pal

References:
• C. Branden and J. Tooze (eds) Introduction to Protein Structure, Garland, 1991

Pre-requisites:
• Undergraduate level familiarity in Physics, Chemistry and Maths.

DS 211 (AUG) 3:0
Numerical Optimization
Introduces numerical optimization with emphasis on convergence and numerical analysis of algorithms as well as applying them in problems of practical interest. Topics include: Methods for solving matrix problems and linear systems that arise in the context of optimization algorithms. Major algorithms in unconstrained optimization (e.g., modified Newton, quasi-Newton, steepest descent, nonlinear conjugate gradient, trust-region methods, line search methods), constrained optimization (e.g., simplex, barrier, penalty, sequential gradient, augmented Lagrangian, sequential linear constrained, interior point methods), derivative-free methods (e.g., simulated annealing, Bayesian optimization, Surrogate-assisted optimization), dynamic programming, and optimal control.

Deepak Subramani

Pre-requisites:
• Basic knowledge of Numerical Methods, Basic knowledge of Linear Algebra, Consent from Advisor
DS 221 (AUG) 3:1

Introduction to Scalable Systems

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

Sathish S Vadhiyar, Yogesh L Simmhan

Pre-requisites:
- Basics of computer systems, Basic data structures and programming, Basic algorithms, Consent of instructor

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.

Venkatesh Babu R, Anirban Chakraborty

References:
- Current Literature

Pre-requisites:
- Basic knowledge of Image Processing, Probability

DS 284 (AUG) 2:1

Numerical Linear Algebra


Murugesan Venkatapathi

Pre-requisites:
- Basics of matrix algebra, Basic programming, Vectors and vector spaces
DS 288 (AUG) 3:0

Numerical Methods


Phaneendra Kumar Yalavarthy

Pre-requisites:
- Consent from Advisor, Good knowledge of basic mathematics, Basic programming skill, Basic knowledge of multivariate calculus and elementary real analysis

DS 290 (AUG) 3:0

Modelling and Simulation


Soumyendu Raha

References:

Pre-requisites:
- Basic course on numerical methods and consent of the instructor.

DS 291 (AUG) 3:1

Finite Elements: Theory and Algorithms


Sashikumaar Ganesan

Pre-requisites:
- Consent from Advisor, Good knowledge of numerical analysis, Basic programming skill
DS 323 (AUG) 1:1
Parallel Computing for Finite Element Methods
This course will provide an introduction to parallel finite element data structure and its efficient implementation in ParMooN (Parallel Mathematics and object oriented Numerics), an open source parallel finite element package. Further, the implementation of the parallel (MPI/OpenMPI) geometric multigrid solver will also be taught. Parallel finite element solution of scalar and incompressible Navier-Stokes equations in two- and three-dimensions using ParMooN (cmg.cds.iisc.ac.in/parmoon/) will also be a part of this course.

Sashikumaar Ganesan

References:

Pre-requisites:
- Consent from Advisor, Good knowledge of finite element methods, C/C++.

DS 255 (JAN) 3:1
System Virtualization
Virtualization as a construct for resource sharing; Re-emergence of virtualization and it's importance for Cloud computing; System abstraction layers and modes of virtualization; Mechanisms for system virtualization – binary translation, emulation, para-virtualization and hardware virtualization; Virtualization using HAL layer – Exposing physical hardware through HAL (example of x86 architecture) from an OS perspective; System bootup process; Virtual Machine Monitor; Processor virtualization; Memory Virtualization; NIC virtualization; Disk virtualization; Graphics card virtualization; OS-level virtualization and the container model; OS resource abstractions and virtualization constructs (Linux Dockers example); Virtualization using APIs – JVM example.

Lakshmi Jagarlamudi

Pre-requisites:
- Consent from Advisor, Basic course on operating systems, Basic programming skill

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-requisites:
- Data Structures and Algorithms, Strong programming experience preferably in Java, Courses like DS 221; DS 252; DS 222; or E0 251
DS 260 (JAN) 3:0
Medical Imaging

Phaneendra Kumar Yalavarthy
Pre-requisites:
• Consent from Advisor, Basic knowledge of system theory, Good knowledge of basic mathematics

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, Anirban Chakraborty
References:
• Current Literature
Pre-requisites:
• Consent from Advisor, Basic knowledge of Computer Vision and Machine Learning, Proficiency in Python, C/C++

DS 289 (JAN) 3:1
Numerical Solution of Differential Equations

Aditya Konduri
Pre-requisites:
• Consent from Advisors, Basic course on numerical methods, Good knowledge of basic mathematics
DS 294 (JAN) 3:0
Data Analysis and Visualization

Data pre-processing, data representation, data reconstruction, machine learning for data processing, convolutional neural networks, visualization pipeline, isosurfaces, volume rendering, vector field visualization, applications to biological and medical data, OpenGL, visualization toolkit, linear models, principal components, clustering, multidimensional scaling, information visualization.

Anirban Chakraborty

Pre-requisites:
• Consent from Advisors, Basic knowledge of numerical methods, Good knowledge of basic mathematics

DS 295 (JAN) 3:1
Parallel Programming

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 and Languages: advanced MPI including MPI-2 and MPI-3, advanced concepts in CUDA programming; Scientific Applications: sample applications include molecular dynamics, evolutionary studies, N-Body simulations, adaptive mesh refinements, bioinformatics; System Software: sample topics include scheduling, mapping, performance modeling, fault tolerance.

Sathish S Vadhiyar

Pre-requisites:
• Consent from Advisor, DS 221 Introduction to scalable systems, A graduate level course on algorithms, Fundamentals of MPI, OpenMP and GPU architectures

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.

Pre-requisites:
• Consent from Advisor, Literature review, Clear idea about the research project

DS 391 (JAN) 3:0
Data Assimilation to Dynamical Systems

Quick introduction to nonlinear dynamics: bifurcations, unstable manifolds and attractors, Lyapunov exponents, sensitivity to initial conditions and concept of predictability. Markov chains, evolution of probabilities (Fokker-Planck equation), state estimation problems. An introduction to the problem of data assimilation (with examples) Bayesian viewpoint, discrete and continuous time cases Kalman filter (linear estimation theory) Least squares formulation (possibly PDE examples) Nonlinear Filtering: Particle filtering and MCMC sampling methods. Introduction to Advanced topics (as and when time permits): Parameter estimation, Relations to control theory, Relations to synchronization.
Soumyendu Raha

References:
- Edward Ott, Chaos in Dynamical Systems, Cambridge press, 2nd Edition, 2002. (or one of the many excellent books on dynamical systems)
- Van Leeuwen, Peter Jan, Cheng, Yuan, Reich, Sebastian, Nonlinear Data Assimilation, Springer Verlag, July 2015.
- Sebastian Reich, Colin Cotter, Probabilistic Forecasting and Bayesian Data Assimilation, Cambridge University Press, August 2015.

Pre-requisites:
- Consent from Advisor, Good knowledge of basic mathematics, Basics of data science

DS 397 (JAN) 2:1
Topics in Embedded Computing

Introduction to embedded processing, dataflow architectures, architecture of embedded SoC platforms, dataflow process networks, compiling techniques/optimizations for stream processing, architecture of runtime reconfigurable SoC platforms, simulation, design space exploration and synthesis of applications on runtime reconfigurable SoC platforms, additional topics including but not limited to computation models for coarse grain reconfigurable architectures (CGRA), readings and case study of REDEFINE architecture, compiler back-ends for CGRAs.

Nandy S K

Pre-requisites:
- Consent from Advisor, Basic knowledge of digital electronics, computer organization and design, Basic knowledge of computer architecture, data structures and algorithms
Centre for Nanoscience and Engineering

M Tech Degree Programme
Centre for Nano science and Engineering

Duration: 2 years

Departmental Core 28 credits

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
<th>Title</th>
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<tbody>
<tr>
<td>NE 215</td>
<td>3:0</td>
<td>Applied Solid State Physics</td>
</tr>
<tr>
<td>NE 241</td>
<td>3:0</td>
<td>Materials Synthesis: Quantum Dots to Bulk Crystals</td>
</tr>
<tr>
<td>NE 205</td>
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0:03     May-July
0:09     August–December
0:15     January June
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.

Manoj Varma, Akshay K Naik

Pre-requisites:
• Lecture notes, hands-on training manuals, Hands-on training manuals, Handouts on detailed process flows and device characterization schedule

NE 202 (AUG) 0:2
Micro AND Nano Fabrication

This course is designed to give training in device processing at the cleanroom facility in CeNSE. The first part of the course teaches students pre-defined modules. This requires students to attend a lab session/week. Specifics change but the module can be one or two of the following: i) p-n junction diode, ii) MOS capacitor iii) MEMS Cantilever iv) Microfluidic channel. The second half of the project which is ~2/3 of course length is a project that must be done in groups of 2-3. The project is expected to be a significant investment of time, that justifies the 0:2 credit weight. Places are limited. CeNSE students get priority.

Shankar Kumar Selvaraja, Sushobhan Avasthi

Co-requisites:
• NE203

NE 203 (AUG) 3:0
Advanced micro- and nanofabrication technology and process


Shankar Kumar Selvaraja, Sushobhan Avasthi

References:
• Stephen A. Campbell, The Science and Engineering of Microelectronic Fabrication
NE 205 (AUG) 3:0

Semiconductor Devices and Integrated Circuit Technology

This is a foundation level course in the area of electronic device technology. Band structure and carrier statistics, Intrinsic and extrinsic semiconductor, Carrier transport, p-n junction, Metal-semiconductor junction, Bipolar Junction Transistor, Heterojunction, MOS capacitor, Capacitance-Voltage characteristics, MOSFET, JFET, Current-Voltage characteristics, Light Emitting Diode, Photodiode, Photovoltaics, Charge Coupled Device Integrated circuit processing, Oxidation, Ion implantation, Annealing, Diffusion, Wet etching and dry plasma etching, Physical vapour deposition, Chemical vapour deposition, Atomic layer deposition, Photolithography, Electron beam lithography, Chemical mechanical polishing, Electroplating, CMOS process integration, Moore’s law, CMOS technology scaling, Short channel effects, Introduction to Technology CAD, Device and Process simulation and modeling

Digbijoy N Nath

References:
• Streetman and Banerjee, Solid State Electronic Devices, Prentice-Hall,

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, waveguides and fiber optics, coherence and lasers, plasmonics.

Ambarish Ghosh, Shankar Kumar Selvaraja

Pre-requisites:
• Bahaa Saleh and Malvin Teich, Fundamentals of Photonics, Wiley and Son (1991) Hecht E, Optics. Addison Wesley, 2001,

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. Review of Quantum Mechanics and solid state physics, Solution of Schrodinger equation for band structure, crystal potentials leading to crystal structure, reciprocal lattice, structure-property correlation, Crystal structures and defects, X-ray diffraction, lattice dynamics, Quantum mechanics and statistical mechanics, thermal properties, electrons in metals, semiconductors and insulators, magnetic properties, dielectric properties, confinement effects

Shivashankar S A, Akshay K Naik

References:
**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. Modeling and design will cover blockset models of MEMS transducers, generally implemented in SIMULINK or MATLAB. Detailed multiphysics modeling may require COMSOL simulations. The course also covers MEMS specific micromachining concepts such as bulk micromachining, surface micromachining and related technologies, micromachining for high aspect ratio microstructures, glass and polymer micromachining, and wafer bonding technologies. Specific case studies covered include Pressure Sensors, Microphone, Accelerometers, Comb-drives for electrostatic actuation and sensing, and RF MEMS. Integration of micromachined mechanical devices with microelectronics circuits for complete implementation is also discussed.

*Saurabh Arun Chandorkar*

**References:**

**NE 231 (AUG) 3:0**

**Microfluidics**

This is a foundation course discussing various phenomena related to fluids and 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, electro-osmosis, electrical double layer (EDL), zeta potential, species and charge transport, particle electrophoresis, AC electrokinetics, surface tension, hysteresis and elasticity of triple line, wetting and long range forces, hydrodynamics of interfaces, surfactants, special interfaces. Suspensions, rheology, nanofluidics, thick-EDL systems, DNA transport and analysis.

*Prosenjit Sen*

**References:**
- Brian J. Kirby, Micro- and Nanoscale Fluid Mechanics, Cambridge University Press
- R. F. Probstein, Physicochemical Hydrodynamics, Wiley Inter-Science

**NE 241 (AUG) 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 aim of 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.

*Srinivasan Raghavan*

**References:**
- 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.

Navakanta Bhat

Pre-requisites:
- Lecture notes

NE 312 (AUG) 3:0
Nonlinear and Ultrafast Photonics

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 nonlinear optical phenomena and Ultrafast lasers in various fields, we believe a good understanding of these principles is essential for students in all science and engineering disciplines, in particular students involved in the area of Photonics, RF and Microwave systems, Optical Instrumentation and Lightwave (Fiber-optic) Communications. In addition, this course intends to prepare students to pursue advanced topics in more specialized areas of optics such as Biomedical Imaging, Quantum optics, Intense field phenomena etc.

Supradeepa V R, Varun Raghunathan

Pre-requisites:

NE 200 (JAN) 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.

Shivashankar S A

References:

NE 201 (JAN) 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.

Manoj Varma, Akshay K Naik
Pre-requisites:
• Lecture notes and hands-on training manuals,-,-

**NE 202 (JAN) 0:1**
**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-requisites:
• Handouts on detailed process flows and device characterization schedule,-,-

**NE 211 (JAN) 3:0**
**Micro/Nano Mechanics**

This is a foundation level course in mechanics which will prepare students to pursue advanced studies related to mechanical phenomena at the micro and nano scales. Basics of continuum theory, continuum hypothesis, elasticity, thermoelasticity, fluid mechanics, heat conduction, electromagnetism, coupled thermal-elastic and electrostatic-elastic systems, MEMS and NEMS structures -- beams, plates, and membranes, scaling of mechanical properties and continuum limits, numerical methods for mechanical modelling, mechanics beyond continuum theory.

**Akshay K Naik, Prosenjit Sen**

References:
• John A. Palesko and David H. Bernstein, Modeling MEMS and NEMS, Chapman and Hall/CRC,-,-

**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 fluids, 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**

References:

**NE 299 (JAN) 0:27**
**Dissertation Project**

243
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

References:

NE 313 (JAN) 3:0

Lasers: Principles and Systems

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

Supradeepa V R

References:

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, Digbijoy N Nath

References:
• Solar Cells, Operating principles, Technology and System Applications, Martin A. Green, Prentice Hall.
• Semiconductor Physics: An Introduction, Kartheinz Seeger, Springer

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 biosensing 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-requisites:
• Lecture notes and selected publications from recent literature. Familiarity with solution of ODEs and PDEs, knowledge of Matlab, Mathematica or an equivalent programming language, elementary probability theory,-,-
Department of Management Studies

Master of Management (M.Mgt) Program

Duration: 2 years

Hard Core: 24 credits

MG 201  3:0 Managerial Economics
MG 211  3:0 Human Resource Management
MG 212  2:1 Behavioural Science
MG 221  2:1 Applied Statistics
MG 232  3:0 Principles of Management
MG 241  3:0 Marketing Management
MG 251  3:0 Finance & Accounts
MG 261  3:0 Operations Management

Stream Core: 12 Credits (to be chosen from either one of the two streams)

Stream 1: Business Analytics Stream
MG 223  3:0 Applied Operations Research
MG 225  3:0 Decision Models
MG 226  3:0 Time Series Analysis and Forecasting
MG 265  2:1 Data Mining

Stream 2: Technology Management Stream
MG 271  3:0 Technology Management
MG 274  3:0 Management of Innovation and Intellectual Property
MG 281  3:0 Management of Technology for Sustainability
MG 298  2:1 Entrepreneurship for Technology Start-ups

Electives: 12 credits

Project: MG 299 0:16 Management Project

Summer Internship: No credits. Every student is required to spend a minimum of eight weeks in an identified industrial enterprise or public sector organization during the summer period after the first two semesters. Alternatively students have the option to get exposure to business incubators, venture capital firms and successful start-ups.
MG 201 (AUG) 3:0
Managerial Economics

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

Balasubrahmanya M H

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

MG 202 (AUG) 3:0
Macroeconomics


Balasubrahmanya M H

References:

MG 212 (AUG) 2:1
Behavioral Science

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

Anjula Gurtoo

References:

MG 221 (AUG) 2:1
Applied Probability and Statistics


Mukhopadhyay C

References:
MG 225 (AUG) 3:0
Decision Models


Parthasarathy Ramachandran

Pre-requisites:

MG 232 (AUG) 3:0
Principles of Management

Scientific techniques of management. Evolution of management thought, contributions of Taylor, Gilbreth, Henri Fayol and others. Levels of authority and responsibilities. Types of managerial organizations, line, staff, committee, etc. Social responsibilities of management, internal and external structure of organizations, charts and manuals, formulation and interpretation of policy, issue of instructions and delegation of responsibility, functional team-work, standards for planning and control.

Yadnyvalkya

References:

MG 241 (AUG) 3:0
Marketing Management


Parthasarathy Ramachandran

Pre-requisites:

MG 242 (AUG) 3:0
Strategic Management

Strategic management process, challenge of globalization, strategic planning in India. Corporate
governance, board of directors. Role and functions of top management. Environmental scanning; industry analysis; internal scanning; organizational analysis. Strategy formulation: situation analysis and business strategy, corporate strategy, functional strategy, strategy implementation and control, strategic alternatives. Diversification, mergers and acquisition

Parthasarathy Ramachandran

References:

MG 246 (AUG) 3:0

Customer Segmentation and Insights

Develop a deep actionable understanding of customers using a disciplined approach to give companies a competitive advantage using customer research, analytics and experimentation. Numeric data, language data and image data analysis, verbal and non-verbal communication skills, and presentation techniques. What is Customer Segmentation? How is it useful for organizations? What are Customer Insights? What are “product-out” verses “market-in” approaches? What is a “purchase journey”? What is Customer Experience Management? Illustrated with examples. How to get a holistic picture (360o view) of the customer base? Collecting quantitative and qualitative (emotions) data about customers. How is customer segmentation done using data analytics? Illustrative examples. What are the different stages in the purchase journey? How do we know which of these “touchpoints” are of value (moments of truth) to target customer segments? How does one benchmark with competition? Some practical approaches to connect with customers to get insights. Determining the “latent needs” of the customer by using image and language data (Voice of Customer), art of active listening and observing customer behavior. Developing the Kano Questionnaire, Conducting the Kano survey. Analyzing the Kano results including cross-tabulation of customer attributes, developing product/ service concepts (experiments), conducting a pilot, evaluating the effectiveness of the experiments. What are the tools available to deliver a differentiated customer experience at those “moments of truths?” How does “digital” play a role in enhancing customer experience?

Parthasarathy Ramachandran

References:

Pre-requisites:
• MG 241 Marketing Management

MG 261 (AUG) 3:0

Operations Management

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

Mathirajan M

References:
**MG 265 (AUG) 3:0**

**Data Mining**


**Parthasarathy Ramachandran**

**References:**
- Jiawei Han and Micheline Kamber, Data Mining: Concepts and Techniques, Morgan Kaufman Publishers 2001.

**MG 271 (AUG) 3:0**

**Technology Management**

Definition of technology, technological transformation process, adaption. Adaption and innovation experiences in selected developed and developing countries. Technology transfer and its relation to technology transformation, diffusion and commercialization, rural technology management. Forward and backward integration. Some concepts in relation to technology management – productivity, employment, human resource and organizational development and corporate strategy. MOT scope and focus, measuring technology content and intensity, organizing the high technology enterprise. Concurrent engineering and integrated product development, managing technology based projects, technology evaluation and selection, leading technology teams.

**Akhilesh K B**

**References:**

**FL 141 (JAN) 3:0**

**Preliminary Course in Russian**

Phonetics, speech patterns, tables, lexical and grammatical exercises and dialogues

**Yadnyvalkya**

**References:**
- I.S. Krishtofova and T.S. Gamzkova, Russian Language For All, L. Muravyova, Verbs of Motion in Russian, Russian Language Publishers

**MG 211 (JAN) 3:0**

**Human Resource Management**

Historical development - welfare to HRM in India. Personnel functions of management. Integrated HRPD system, human resource planning, job analysis, recruitment and selection, induction, performance appraisal and counseling, career planning and development, assessment center, wage and salary administration, 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.
Akhilesh K B

References:
- Werther and Davis

MG 222 (JAN) 3:0
Regression and Time Series Analysis

Mukhopadhyay C

References:

MG 223 (JAN) 3:0
Applied Operations Research

Mathirajan M

References:

MG 226 (JAN) 3:0
Advanced Analytics

Mukhopadhyay C

MG 251 (JAN) 3:0
Finance and Accounts

Shashi Jain

Pre-requisites:

MG 258 (JAN) 3:0
Financial instruments and risk management strategies
Shashi Jain

MG 274 (JAN) 3:0
Management of Innovation and Intellectual Property

Organizational and technological innovation – definition of innovation vs inventions, role of organizational design and processes – strategic role of intellectual property protection in case studies, the R&D value chain, stage gates, differences in priority with the R&D value chain, NPD - international, national, organizational, individual actors, organizations and vehicles to manage intellectual property, critical steps in managing R&D, process management during stage gates for patent searches, technology landscaping, specification writing, timeline management, rights and responsibilities in competitive technology environments, innovative inventions, commercial potential, processes to enhance technological know-how transfer, open source approach, incubators, assessing patent value, information technology support systems in managing innovation and intellectual property, prior art laboratories sessions and working with a client.

Parthasarathy Ramachandran

References:

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

References:
MG 281 (JAN) 3:0
Management of Technology for Sustainability


Balachandra P

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

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
INTERDISCIPLINARY PROGRAM - CYBER PHYSICAL SYSTEM

The Robert Bosch Centre for Cyber-Physical Systems (RBCCPS) @ IISc is a research and academic centre, under the Division of Interdisciplinary Research. The centre focuses on foundational and applied research to solve cutting edge problems in Robotics involving advanced machine learning techniques, Connected Autonomous Systems like drones and 5G-enabled autonomous vehicles, and Socio-Technical Systems like urban transportation systems and Smart Cities. The Centre faculty are drawn from various existing departments. The Centre runs an interdisciplinary PhD program in Cyber-Physical Systems and offers various short and semester long courses.

CP 313 (Aug) 2:1
Autonomous Navigation

This course will be co-taught with Raghu Krishnapuram. Autonomous robots (including self-driving cars and drones) are good examples of highly complex cyber-physical systems (CPSs) with an array of sensors and actuators that may possess external connectivity to other infrastructure. Autonomous robots are set to be game changers in several areas such as infrastructure maintenance, transportation, public safety, rescue operations, disaster response, agriculture, mining, surveillance, public safety, health care, unmanned cargo, and exploration. Autonomous navigation lies at heart of autonomous robots, and involves a highly multidisciplinary approach. It includes a variety of subject areas such as perception and sensor technologies (such as IMU, GPS, LiDAR, and wheel odometry), behaviour modelling, trajectory prediction, localization and mapping methods, and motion/path planning in the presence of obstacles. This 14-week course will cover the main theoretical concepts and practical approaches to autonomous navigation (including recent advances in visual odometry based on deep learning) through a combination of lectures, associated hands-on lab assignments as well as individual and group projects.

Chiranjib Bhattacharyya

References:

Prerequisites:
- (E2 202) or Probability and Statistics (E0 232) or its equivalent
- Linear Algebra and Applications (E0 219) or its equivalent

Co-Requisites:
- Basic knowledge of optimization methods, algorithm design, programming and machine learning will be assumed.