Scheme of Instruction

Academic Year 2020-21
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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, while a course with 3:0 credits indicates a course with 3 lecture hours and no laboratory session.

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

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

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

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

25th September 2020

Raghuraman N. Govardhan
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 in fundamental and applied sciences, such as biology, chemistry, physics, medicine, agriculture and technology, 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 Program for students registering for research conferment's at the Institute. For individual requirements, the students are advised to approach the Departmental Curriculum Committee.

The Department of Biochemistry offers a program of study concentrating on a molecular approach towards understanding biological phenomena. The program 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, experimental and field based research in plant and animal ecology, evolution and behavior. The program of instruction consists of lectures, laboratory work, seminars and special assignments.

The Department of Microbiology and Cell Biology offers courses in microbiology, infectious diseases, cell biology, molecular biology, genetic engineering, RNA biology, developmental genetics, cancer biology and ageing and regeneration. 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, biophysical techniques, cellular neurophysiology and computational neuroscience.

The courses offered in the Department of Molecular Reproduction, Development and Genetics include those on signal transduction, gene expression and development, genetics and genomic medicine, molecular oncology, aging and regeneration.

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

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

Prof. Usha Vijayraghavan
Dean,
Division of Biological Sciences
### Integrated PhD (Biological Sciences)

#### Course Work:

**Core Courses: 14 credits (6 Core courses in Aug)**

1. DB201 (AUG) 2:0  Mathematics and Statistics for Biologists  
2. DB202 (AUG) 2:0  General Biology  
3. BC203 (AUG) 3:0  General Biochemistry  
4. MB201 (AUG) 2:0  Biophysical Chemistry  
5. MC203 (AUG) 3:0  Essentials in Microbiology  
6. RD 201 (AUG) 2:0/DB204  Genetics

**Projects: 18 Credits:**

- DB212 0:6  Project –I  JAN  
- DB225 0:6  Project –II  AUG  
- DB327 0:6  Project –III  JAN

**Elective Courses: 32 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

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:

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

PurusharthRajyaguru, Sathees C. Raghavan, Patrick D Silva, Ganesh Nagaraju

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

DipshikhaChakravortty, Utpal Tatu

DB 212 (JAN) 0:6  
Biological Science

DipshikhaChakravortty

DB 327 (JAN) 0:6  
Biological Science  
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.

DipshikhaChakravortty
### Biochemistry

**BC 201 (AUG) 2:0**  
Cell Biology  

Shikha Laloraya, Utpal Tatu, Dipankar Nandi, Patrick D Silva  
**Pre-requisites:**  

**BC 202 (AUG) 2:0**  
Proteins: Structure and Function  
Purification and characterization of enzymes/proteins. Determination of primary/secondary/tertiary/quaternary structures, conformational properties of polypeptide chains; Mechanism of Protein folding; Enzyme catalysis – steady state kinetics, allosteric enzymes, kinetics of interactions of ligands, protein engineering, enzyme mechanisms.

Nagasuma R Chandra, Narasimha Rao D, Utpal Tatu  
**Pre-requisites:**  

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

Purusharth Rajyaguru, Sathees C. Raghavan, Patrick D Silva, Ganesh Nagaraju  
**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, Sandeep M Eswarappa, Sathees C. Raghavan  
**Pre-requisites:**  
- Goldsby, R.A., Kindt, T.J., Osborne
The Center for Ecological Sciences has excellent facilities for theoretical, experimental and field based research in plant and animal ecology, evolution and behavior. The programme of instruction consists of lectures, laboratory work, seminars and special assignments.

**EC 101 (AUG) 1:0**  
**Process of Scientific Thinking**  
Approaches of scientific practice and research conduct. Historical perspective of various philosophies of science and the process of scientific thinking (e.g. deduction, induction and inference by best explanation). Ethics in conducting, writing, and publishing science (including plagiarism), best practices for replicable research. How to read and review scientific literature critically.

**Maria Thaker**

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

**Pre-requisites:**
- Targeted for PhD and MSc students in the field of ecology and evolution. Interested students in other fields should email the instructor in advance.

**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, predator-prey interactions.

**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 305 (AUG) 2:1
Quantitative Ecology: Research Design and Inference

This course will focus on study design and statistical modelling in ecology. We will examine elements of effective study design, common pitfalls in study design and data collection, and the confrontation of ecological hypotheses with data using different statistical approaches and frameworks of inference. Throughout, we will examine concepts using examples from ecology, animal behaviour and evolution. The course will aim to provide proficiency to carry out various statistical techniques commonly used in ecology using the software R. The main topics that will be covered are: 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

Pre-requisites :
- As a single entry: A background in ecology, behaviour or evolution, either in the form of courses taken or projects completed, currently being carried out or currently being planned, or equivalent in ecology/behaviour/evolution

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

References :

EC 202 (JAN) 2:0
Ecology: Pattern and Process

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

Umesh Srinivasan, Kartik Shanker

References :
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.

Kartik Sunagar, Praveen Karanth K  
References :  

EC 309 (JAN) 2:0  
**Ecosystems and Global Change**  
This course will 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 :  
- EC202
### Molecular Biophysics Unit

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<td>Prof. Raghavan Varadarajan <a href="mailto:varadar@iisc.ac.in">varadar@iisc.ac.in</a></td>
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<td>Molecular Spectroscopy and its Biological Applications</td>
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<td>Prof. Siddhartha P Sarma, Dr. Mahavir Singh</td>
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<td>MB205</td>
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<td>Dr. Aravind Penmatsa, Prof. Kaza Suguna</td>
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<td>MB206</td>
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<td>Prof. N Srinivasan, Dr. Anand Srivastava, Dr. Mahavir Singh</td>
<td>M, W, F 11:00 AM - 12:00 PM</td>
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<td>MB214</td>
<td>Neuronal Physiology and Plasticity</td>
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<td>Prof. Rishikesh Narayanan</td>
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<td>Prof. Siddhartha P Sarma, Dr. Ashok Sekhar</td>
<td>M, W, F 2:00 PM - 3:00 PM</td>
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**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.

Mahavir Singh, Siddhartha P Sarma

**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.

Aravind Penmatsa, Kaza Suguna

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.

Mahavir Singh, Anand Srivastava, Srinivasan N

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

Pre-requisites:
**MB 305 (AUG) 3:0**

**Biomolecular NMR Spectroscopy**


**Ashok Sekhar, Siddhartha P Sarma**

**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
Dept of Microbiology and Cell Biology

MC 203 (AUG) 3:0

Essentials in Microbiology

Fascinating world of microbes; Principles of microscopy; Microbial taxonomy, Microbial diversity, evolution and genomics; Mechanisms of horizontal gene transfer including genome transplantation, Microbes as model systems of development, Microbes as bioreactors and sensors; bioremediation; bacterial cell structure and function; Bacterial physiology and nutrition; Bacteriophages, Plasmids and Transposons; Understanding and combating bacterial pathogenesis; Antibiotics- mechanisms of drug resistance and mode of action; Quorum sensing and biofilms; Host-pathogen interactions and mechanisms of immune surveillance; PRR and their role in pathogenesis; TH subsets and modulation by pathogens; Diagnostics and vaccine development; Origin of cellular life; Biogeography of microbial diversity (is everything everywhere?); Host associated and free-living microbes; Mechanisms of microbial interactions; Causes, consequences, and evolution of physiological heterogeneity in bacterial populations; Bacterial predation, and survival strategies.

Amit Singh, Samay Ravindra Pande, Dipshikha Chakravortty

References:

MC 205 (AUG) 2:0

Pathogen - Host interactions and immune evasion mechanisms

Pathogen - Host interactions and immune evasion mechanisms The vertebrate host has evolved numerous mechanisms to shield itself against the onslaught of the myriad pathogens around it. The host uses toll like receptors to recognize pathogens, and deploys effective weapons from its impressive arsenal to eliminate pathogens. This course will utilize multiple host-pathogen pairs as models to demonstrate the innumerable mechanisms utilized by pathogens of viral, bacterial and parasitic origin to subvert the host and enhance their own survival. Secretion systems of bacteria: Type I, II, III, IV, V overview of ABC exporters and importers, Plant Pathogen interactions (Xanthomonas Citrobactor, Erwinia); Virulence gene expression, intracellular 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.

Shashank Tripathi, Balaji Kithiganahalli, Dipshikha Chakravortty

References:
MC 206 (AUG) 2:0
RNA BIOLOGY

Saibal Chatterjee, Purusharth Rajyaguru

References:

MC 207 (AUG) 3:0
Molecular Biology

Nagaraja V, Umesh Varshney

References:
•  (1) Lewin’s Genes X, Lewin,B., Krebs,J.E.

MC 208 (AUG) 2:0
Principles of Genetic Engineering

Subba Rao Gangisetty, Shashank Tripathi
References:

Pre-requisites:
• Basic biology, chemistry and physics

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; Flowcytometry; Pulse-chase and subcellular fractionation; Proteomics and Protein-protein interaction approaches and genome-wide RNAi or small molecular screens to study the various cellular pathways.

Subba Rao Gangisetty, Sachin Kotak

References:
• (1) Molecular Biology of The Cell, Fifth edition, Alberts et al.

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.

Samay Ravindra Pande, Utpal Nath, Upendra Nongthomba

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

Introduction to Cancer Biology: immortalization, transformation, metastasis; causes of cancer: initiators and promoters, carcinogens, tumor viruses, sporadic and familial cancer; genetic alterations: mutation, deletion, insertion, aneuploidy, chromosome translocation and gene amplification; multistep carcinogenesis model; cancer diagnosis and treatment; cell cycle and cancer: cell cycle checkpoints, G1/S checkpoint, G2/M checkpoint, cyclins and cyclin dependent kinases, CDK inhibitors - p16, p21 and p27; oncogenes: growth factors, growth factor receptors, G protein/signal transduction, tyrosine and serine/threonine kinases and transcription factors; tumor suppressor genes: p53, RB, BRCA1, BRCA2, APC and WT1; mismatch repair, telomerase, DNA methylation, protein phosphorylation/dephosphorylation and degradation events; transformation by RNA and DNA tumor viruses: Adenovirus, Simian Virus 40 and Human papilloma virus, Oncogene-tumor suppressor interactions; apoptosis and cancer, cancer as a tissue: stroma, angiogenesis; cancer stem cells; cancer gene therapy.

Kumaravel Somasundaram, Annapoorni Rangarajan

References:

MC 211 (JAN) 3:0
Molecular basis of Ageing and Regeneration

Mechanisms of Ageing and Regeneration; model systems for studying Ageing and Regeneration; role of cellular processes such as transcription, translation, posttranslational modifications; signalling mechanisms; cellular senescence; genetic basis of ageing and longevity; Ageing and Diseases; Organ Senescence; Obesity/Diabetes/Cardiovascular diseases/Muscle degeneration; interventions to delay ageing and/or enhance life span

Varsha Singh, Purusharth Rajaguru, Nagalingam Ravi Sundaresan

References:
- Molecular Biology of Aging (Cold Spring Harbor Monograph Series)

MC 214 (JAN) 2:0
Basic and Applied Virology

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

Shashank Tripathi

References:
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.

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 hos spatio-temporal dynamics of signaling pathways regulate cellular physiology. Genetic analysis of signalling pathways in model organisms.

Deepak Kumar Saini, Ramray Bhat
References:
• Cell Signaling - Principles and Mechanisms; Lim, Mayer and Pawson (2015) Garland Science

RD 205 (JAN) 2:0
Genetics and Genomic Medicine
History of concepts in genetics; Genes and Genomes; Mutations; Genetic recombination and repair; 3-point cross; Tetrad analysis; GAL4-UAS system for genetic analysis; CRISPR-CAS9 system for genetic analysis; Population genetics; Types of human genetic disorders; Chromosomal aberrations in humans; Trinucleotide repeats and genetic disorders; Linkage analysis and gene discovery; Neuromuscular disorders; Genomic imprinting; Multifactorial inheritance; Genetic risk; Cancer genetics; mtDNA disorders.

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

References:
- Principles of Regenerative Biology by Bruce Carlson.

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:
- Robbins Basic Pathology, 9th Edition
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
References:
• Tue, Fri 9:00

NS 203 (AUG) 2:0
Cognitive Neuroscience
Methods in cognitive neuroscience, attention, decision making, executive functions, emotion, reward processing.
Sridharan Devarajan, srikantPadmala

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

Scheme of Instruction 2020 - 2021
NS 301 (JAN) 2:0
Topics in Systems and Cognitive Neuroscience
Critical readings and grant writing on various topics in systems and cognitive neuroscience.

Aditya Murthy, Sridharan Devarajan, 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, Narendrakumar Ramanan, Deepak Kumaran Nair
Pre-requisites:
• NS 202 or NS204
Preface

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

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

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

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

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

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

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

<table>
<thead>
<tr>
<th>CourseCode</th>
<th>CourseName</th>
<th>Credits</th>
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<td>CD 211</td>
<td>Physical Chemistry I Quantum Chemistry and Group Theory</td>
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<tr>
<td>CD 212</td>
<td>Inorganic Chemistry Main group and coordination chemistry</td>
<td>3:0</td>
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<tr>
<td>CD 213</td>
<td>Organic Chemistry Structure and Reactivity</td>
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<td>CD 214</td>
<td>Basic Mathematics</td>
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<td>CD 215</td>
<td>Organic &amp; Inorganic Chemistry Laboratory</td>
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<td>CD 402</td>
<td>Molecular Spectroscopy, Dynamics and Photochemistry</td>
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<td>CD 221</td>
<td>Physical Chemistry II: Statistical Mechanics</td>
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<td>CD 222</td>
<td>Material Chemistry</td>
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<td>CD 241</td>
<td>Research Project</td>
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<tr>
<td>CD 301</td>
<td>Advanced NMR Spectroscopy</td>
<td>3:0</td>
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</tbody>
</table>

### CD 204 (AUG) 3:0

**Chemistry of Materials**

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

**Natarajan S**

Pre-requisites :

### 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

**Upendra Harbola**

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

Abhishake Mondal, Jemmis E. D
References :
• Shriver D.F, Atkins P.W. and Langford C.H., Inorganic Chemistry, Freeman, NY

CD 213 (AUG) 3:0
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 :
• Current Literature.
Refererences :
• Successful completion of UC201 and 205 for UG

CD 214 (AUG) 3:0
Basic Mathematics

Balaram Sahoo
References :
• Thomas, G. B.,Finney, R.L., Calculus and Analytical Geometry
CD 241 (AUG) 0:14  
Research Project  
Ravishankar Narayanan

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.  

Sai G Ramesh

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  

Prabeer Barpanda, Karuna Kar Nanda  
References :  

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:

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.

CD 225 (JAN) 0:4
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, Subinoy Rana
References:
- (c) Relevant literature from Chemical Education (ACS Publications) and other pedagogic Chemistry Journals

CD 241 (JAN) 0:14
Research Project
Ravishankar Narayanan

CD 301 (JAN) 3:0
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
References:
Dept of Inorganic and Physical Chemistry

IP 203 (AUG) 3:0

**Group Theory and Molecular Spectroscopy**


**References:**
- I. N. Levine, *Molecular Spectroscopy*
- J. L. McHale, *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**


**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.

**References:**
**IP 312 (AUG) 3:0**  
**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, metalloccenes. 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)

**IP 322 (JAN) 3:0**  
**Polymer Chemistry**  

Ramakrishnan S  
References :  
- P. J. Flory, Principles of Polymer Chemistry  
- G. Odian, Principles of Polymerization  
- P. C. Hiemenz and T. 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)  
IP 326 (JAN) 3:0

**Time-dependent statistical Mechanics**

Brief survey of equations of motion in classical mechanics; phase space and the Liouville equation; equilibrium time correlation functions (TCF's) and their properties; simple, solvable models of TCFs; linear response theory and transport coefficients; projection operators and generalized equations of motion; functional calculus and diffusion equations, including Fokker-Planck and Smoluchowski equations; chemical reaction dynamics and the Kramers equation; stochastic processes in biology; fluctuation theorems in far from equilibrium systems

**Binny J Cherayil**

**References :**
- D. A. McQuarrie, Statistical Mechanics
- R. Zwanzig, Nonequilibrium Statistical Mechanics
- V. Balakrishnan, Elements of Nonequilibrium Statistical Mechanics

**Pre-requisites :**
- A course in equilibrium statistical mechanics
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.

Balaram Sahoo, Karuna Kar Nanda

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

**MR 309 (AUG) 3:0**

**Introduction to Supramolecular Chemistry**

Course description: Supramolecular chemistry is "chemistry beyond the molecule". It is an interdisciplinary field that covers the physical, chemical and biological properties of complex chemical species held together mainly by non-covalent interactions. This course provides an introduction to the field, and discusses the intermolecular forces that dictate the formation of supermolecules and supramolecular assemblies and their properties. In addition, current trends are discussed using recent publications in this area. Course outline: This course is designed to be modular and includes the following topics: Molecular recognition, Host-Guest Chemistry; Receptors, Coordination and the “Lock and Key” Analogy; Chelate, Conformational and Macrocyclic Effects; Pre-organisation and Complementarity; Thermodynamic and Kinetic Selectivity; Selectivity and Solution Behaviour of Crown Ethers, Cryptands, Spherands; Complexation of Organic Cations; Biological anion receptors; Anti-crowns and Coordination Interactions; Inorganic Solid-State Clathrate compounds; clathrates of organic hosts, intracavity complexes of neutral molecules (Fullerenes, Cucurbiturils, and Cyclodextrins): Solution and Solid State Binding; Metal organic frameworks (MOF); Catenanes, Rotaxanes and Helicates; Role of Positive Cooperativity; Structure and function of DNA; Supramolecular Reactivity, Liquid Crystals, Dendrimers, MOF’s, Electronic devices (switches, wires and rectifiers) and non-linear optical materials.

Subinoy Rana

References:

Pre-requisites:
- The course is open to all PhD, Master and Undergraduate (3rd year or higher) students having done basic organic chemistry.
Organic Chemistry

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.

Mrinmoy De, Uday Maitra
Pre-requisites:
- Anslyn,E.V.,andDougherty,D.A.,Modern

OC 231 (AUG) 3:0
Chemistry of Proteins and Peptides

Erode N Prabhakaran
References:
Pre-requisites:
- Basic principles of Organic Chemistry, Basic Structural knowledge of molecules.

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 organometallic 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:
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; anhydro sugars; 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

Jayaraman N
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 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

SS 201 (AUG) 3:0
Thermodynamics and Statistical Mechanics
Review of thermodynamics, postulates, ensembles, classical and quantum statistics. Application to blackbody radiation, Bose-Einstein Condensation, electron conduction in metals, specific heats of solids, classical fluids and phase transitions.

Govardhan P Reddy
References :
• H.B. Callen, Thermodynamics and an Introduction to Thermo Statistics
• E. Fermi, Thermodynamics
• D. A. McQuarrie, Statistical Mechanics
Pre-requisites :
• Basic Thermodynamics

SS 202 (AUG) 3:0
Introductory Quantum Chemistry

Vivek Tiwari
References :
• 1. Cohen-Tannoudji, Diu and Laloe, Quantum Mechanics. 2. J.J. Sakurai, Modern Quantum Mechanics, 3. A. Szabo and N. Ostlund, Modern Quantum Chemistry
Pre-requisites :
• Ira Levine, Quantum Chemistry and P.W. Atkins, Molecular Quantum Mechanics

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 elementary electrolyte theory and its applications to electrochemical systems such as batteries, fuel cells, electrochemical transistors. Introduction to heterogeneous catalysis and mass transport in electrochemical systems will also be covered.

Naga Phani B Aetukuri
References :
• Electrochemical Methods: Fundamentals and Applications by Bard and Faulkner
• Electrochemical Systems by Newman and Thomas-Aliya
• 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**


**Anshu Pandey, Satish Amrutrao Patil**

**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. Kaushal Verma
Dean
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>
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<tbody>
<tr>
<td>Core courses</td>
</tr>
<tr>
<td>Electives</td>
</tr>
<tr>
<td>Project</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 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:
- 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

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:
- Aschroft and Mermin, Solid State Physics
Pre-requisites:
- Basic mathematics and Linear Algebra

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.

ParthaPratim Mondal
References:
- Book
Pre-requisites:
- Knowledge of C and MATLAB Programming

IN 270 (AUG) 3:0
Digital Signal Processing

Jaya Prakash
References:
- Current Literature

IN 201 (JAN) 3:0
Fundamentals of Metamaterials
Fundamental physics, the designs and the engineering aspects of metamaterials, phononic and photonic metamaterials, bandgap materials, three-dimensional and two-dimensional metasurfaces, nanostructured plasmonic surfaces, MEMS fabrication, effective media with single and double negative properties, state-of-the-art applications for antennas, waveguides, cloaking metamaterial, devices and components, Sensing applications.

Abha Misra
References:
- Metamaterials: Physics and Engineering Explorations, Publisher: Wiley-Blackwell, Edited by Nader Engheta and Richard W. Ziolkowski

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

Sanjiv Sambandan
References:

IN 222 (JAN) 2:1

Sensors and Transducers Laboratory
Sensor development and signal processing, temperature sensor, hall sensor, noise analysis, Dynamic modeling and system identification, DC motor, Induction motor, water bath, Actuation, piezo-actuation, bimetallic strip, magnetic actuation, Control systems, One degree of freedom control, two degree of freedom control, PID control, Lead-lag compensation

Atanu Kumar Mohanty, Jayanth G R, Sanjiv Sambandan, Sai Siva Gorthi, Chandni U, Asha Bhardwaj, Dr. Baladitya Suri

References:

Pre-requisites:
• IN 221

IN 223 (JAN) 3:0

Advanced Signal Processing

Jaya Prakash

References:

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
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:

Optical Metrology

Sai Siva Gorthi

Optical materials and devices

Introduction, Fundamentals of semiconductors and optoelectronic devices, photodetector, LED, LASER, optical properties of thin films and noble metals, Fabrication methods- chemical and physical techniques, Surface Plasmon Polariton, Metasurface, Metasurface applications in sensing and non-linear light generation, Optical fibers and Waveguides, Fiber drawing process, Fiber materials, multi-material micro-structured fibers, multi-material fibers for electronic and photonic applications, Integrated photonics-material choice and applications

Tapajyoti Das Gupta

References:

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:

Dissertation Project
Dept of Mathematics

The department is active in research in most areas of pure and applied mathematics, including algebra and number theory, analysis, discrete mathematics, geometry/topology, mathematical finance, numerical analysis, partial differential equations, probability, representation theory, and time-series analysis.

The department has a Ph.D. programme as well as an integrated Ph.D. programme. The department participates in the undergraduate programme of IISc: undergraduate students can opt for mathematics as a major or a minor.

Courses Offered in AUG 2020 Semester:

<table>
<thead>
<tr>
<th>Course Number</th>
<th>Credits</th>
<th>Course Name</th>
<th>Nature</th>
</tr>
</thead>
<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>
</tr>
<tr>
<td>MA 219</td>
<td>3:1</td>
<td>Linear Algebra</td>
<td>Core</td>
</tr>
<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>
</tr>
<tr>
<td>MA 261</td>
<td>3:0</td>
<td>Probability Models</td>
<td>Core</td>
</tr>
<tr>
<td>MA 223</td>
<td>3:0</td>
<td>Functional Analysis</td>
<td>Core</td>
</tr>
<tr>
<td>MA 232</td>
<td>3:0</td>
<td>Introduction to Algebraic Topology</td>
<td>Core</td>
</tr>
<tr>
<td>MA 226</td>
<td>3:0</td>
<td>Partial Differential Equations</td>
<td>Core</td>
</tr>
<tr>
<td>MA 302</td>
<td>3:0</td>
<td>Mechanics</td>
<td>Elective</td>
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<tr>
<td>MA 307</td>
<td>3:0</td>
<td>Riemann Surfaces</td>
<td>Elective</td>
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<tr>
<td>MA 308</td>
<td>3:0</td>
<td>Basic Algebraic Geometry</td>
<td>Elective</td>
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<tr>
<td>MA 326</td>
<td>3:0</td>
<td>Fourier Analysis</td>
<td>Elective</td>
</tr>
<tr>
<td>MA 336</td>
<td>3:0</td>
<td>Topics in Riemannian Geometry</td>
<td>Elective</td>
</tr>
<tr>
<td>MA 354</td>
<td>3:0</td>
<td>Topics in Number Theory</td>
<td>Elective</td>
</tr>
<tr>
<td>MA 361</td>
<td>3:0</td>
<td>Probability Theory</td>
<td>Elective</td>
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<tr>
<td>MA 365</td>
<td>3:0</td>
<td>Topics in Gaussian Processes</td>
<td>Elective</td>
</tr>
<tr>
<td>MA 381</td>
<td>3:0</td>
<td>Topics in Several Complex Variables</td>
<td>Elective</td>
</tr>
</tbody>
</table>

Courses Offered in JAN 2021 semester:

<table>
<thead>
<tr>
<th>Course Number</th>
<th>Credits</th>
<th>Course Name</th>
<th>Nature</th>
</tr>
</thead>
<tbody>
<tr>
<td>MA 213</td>
<td>3:1</td>
<td>Algebra II</td>
<td>Core</td>
</tr>
<tr>
<td>MA 222</td>
<td>3:1</td>
<td>Measure &amp; Integration</td>
<td>Core</td>
</tr>
<tr>
<td>MA 224</td>
<td>3:1</td>
<td>Complex Analysis</td>
<td>Core</td>
</tr>
</tbody>
</table>

Scheme of Instruction 2020 - 2021
### Scheme of Instruction 2020 - 2021

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Credits</th>
<th>Course Title</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>MA 229</td>
<td>3:0</td>
<td>Calculus on Manifolds</td>
<td>Core</td>
</tr>
<tr>
<td>MA 241</td>
<td>3:1</td>
<td>Ordinary Differential Equations</td>
<td>Core</td>
</tr>
<tr>
<td>MA 215</td>
<td>3:0</td>
<td>Introduction to Modular Forms</td>
<td>Elective</td>
</tr>
<tr>
<td>MA 278</td>
<td>3:0</td>
<td>Introduction to Dynamical Systems Theory</td>
<td>Elective</td>
</tr>
<tr>
<td>MA 304</td>
<td>3:0</td>
<td>Topics in Harmonic Analysis</td>
<td>Elective</td>
</tr>
<tr>
<td>MA 312</td>
<td>3:0</td>
<td>Commutative Algebra</td>
<td>Elective</td>
</tr>
<tr>
<td>MA 319</td>
<td>3:0</td>
<td>Algebraic Combinatorics</td>
<td>Elective</td>
</tr>
<tr>
<td>MA 321</td>
<td>3:0</td>
<td>Analysis III</td>
<td>Elective</td>
</tr>
<tr>
<td>MA 338</td>
<td>3:0</td>
<td>Differentiable Manifolds &amp; Lie Groups</td>
<td>Elective</td>
</tr>
<tr>
<td>MA 363</td>
<td>3:0</td>
<td>Probability in higher dimensions</td>
<td>Elective</td>
</tr>
<tr>
<td>MA 380</td>
<td>3:0</td>
<td>Introduction to Complex Dynamics</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.

*Harish Seshadri*

**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**


*Mahesh Ramesh Kakde, Soumya Das*

**References:**

**Pre-requisites:**
- UM 203
MA 219 (AUG) 3:1
Linear algebra

Fields and linear equations over fields, Vector spaces: Definition, basis and dimension, direct sums. Linear transformations: definition, the Rank-Nullity Theorem, the algebra of linear transformations. Dual spaces, Determinants, Eigenvalues and Eigenvectors, the characteristic polynomial, the Cayley-Hamilton Theorem, the minimal polynomial, and algebraic and geometric multiplicities. Diagonalization. The Jordan canonical form. Bilinear forms: symmetric, skew-symmetric and Hermitian forms, Sylvester's law of inertia, Spectral theorem for Hermitian and normal operators on finite-dimensional vector spaces. Singular value decomposition. Tensor products and exterior algebra.

Apoorva Khare

References:
• Lang S. Linear Algebra (3rd Ed.) Springer-Verlag (UTM), 1989.

Pre-requisites:
• UM 102

MA 221 (AUG) 3:0
Analysis I

Construction of the field of real numbers and the least upper-bound property. Review of sets, countable and 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.

Thirupathi Gudi

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, Orthornormal sets, Orthogonal complements, Bounded operators on a Hilbert space up to (and including) the spectral theorem for compact, self-adjoint operators.

Gadadhar Misra

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 226 (AUG) 3:0

Complex Analysis II

Harmonic and subharmonic functions, Green’s function, and the Dirichlet problem for the Laplacian; the Riemann mapping theorem (revisited) and characterizing simple connectedness in the plane; Picard’s theorem; the inhomogeneous Cauchy–Riemann equations and applications; covering spaces and the monodromy theorem.

Kaushal Verma

References:
• Narasimhan, R., Complex Analysis in One Variable, 1st ed. or 2nd ed. (with Y. Nievergelt), Birkhauser (2nd ed. is available in Indian reprint, 2004).

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.

Basudeb Datta

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.

Mrinal Kanti Ghosh
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 302 (AUG) 3:0

Mechanics
This is an introductory course on the foundations of mechanics, focusing mainly on classical mechanics. The laws of classical mechanics are most simply expressed and studied in the language of symplectic geometry. This course can also be viewed as an introduction to symplectic geometry. The role of symmetry in studying mechanical systems will be emphasized. The core syllabus will consist of Lagrangian mechanics, Hamiltonian mechanics, Hamilton-Jacobi theory, moment maps and symplectic reduction. Additional topics will be drawn from integrable systems, quantum mechanics, hydrodynamics and classical field theory.

Kaushal Verma

References:

Pre-requisites:
- Calculus on manifolds; rudiments of Lie theory (the equivalent of Chapter 1, Chapter 2, and Section 4.1 of "Foundations of mechanics" by Abraham and Marsden).

MA 307 (AUG) 3:0

Riemann surfaces
Riemann surfaces are one-dimensional complex manifolds, obtained by gluing together pieces of the complex plane by holomorphic maps. This course will be an introduction to the the theory of Riemann surfaces, with an emphasis on analytical and topological aspects. After describing examples and constructions of Riemann surfaces, the topics covered would include branched coverings and the Riemann-Hurwitz formula, holomorphic 1-forms and periods, the Weyl's Lemma and existence theorems, the Hodge decomposition theorem, Riemann's bilinear relations, Divisors, the Riemann-Roch theorem, theorems of Abel and Jacobi, the Uniformization theorem, Fuchsian groups and hyperbolic surfaces.

Subhojoy Gupta
References :

Pre-requisites :
• Topology (MA 231) or equivalent
• Complex Analysis (MA 224) or equivalent
• Introduction to Algebraic Topology (MA 232) or equivalent.

MA 308 (AUG) 3:0
Basic Algebraic Geometry
The material to be covered will include: Affine algebraic sets: Zariski topology, irreducible components, Hilbert Nullstellensatz theorem, maps of algebraic sets Algebraic varieties: Definitions, affine algebraic varieties, projective varieties, morphisms Rational functions and rational maps Algebraic curves, Bézout’s theorem * Riemann-Roch theorem

Radhika Ganapathy

References :

Pre-requisites :
• Algebra II (MA 213)
• The course will assume that that the student is comfortable with Abstract Algebra at the level of Galois theory.

MA 326 (AUG) 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.

Thangavelu S

References :

Pre-requisites :
• MA 223

MA 336 (AUG) 3:0
Topics in Riemannian Geometry
Bochner formula, Laplace comparison, Volume comparison, Heat kernel estimates, Cheng-Yau gradient estimates, Cheeger-Gromoll splitting theorem, Gromov-Haudorff convergence, epsilon regularity, almost rigidity, quantitative structure theory of Riemannian manifolds with Ricci curvature bounds. If time permits, we will discuss the proof of the co-dimension four conjecture due to Cheeger and Naber.

Ved V Datar

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

Pre-requisites :
• MA 333 - Riemannian Geometry
MA 354 (AUG) 3:0

Topics in Number Theory

The goal is to give an introduction to adeles and some of their uses in modern number theory, discussing also some topics which are not too common in textbooks. Topics to be covered: absolute values and Ostrowski’s Theorem; classification of locally compact fields; definition of adeles and some applications (finiteness of class number and of the generators of the group of S-units; structure of modules over Dedekind domains; applications to the geometry of curves); an introduction to the Strong Approximation Theorem; adelic points of varieties and schemes; possibly other topics (depending on time left and interests of the audience; for example Tate’s thesis, quasi-characters of the idele class group and p-adic L-functions).

Mahesh Ramesh Kakde

References :
• J. W. S. Cassels and A. Fröhlich (editors), Algebraic Number Theory, Papers from the conference held at the University of Sussex, Brighton, September 1–17, 1965.

Pre-requisites :
• a good background in commutative algebra (inverse limits, I-adic completion, Galois theory, possibly some familiarity with Dedekind domains)
• some previous knowledge of algebraic number theory should be useful.

MA 361 (AUG) 3:0

Probability theory

Review of Measure Theory, various modes of convergence of random variables, convergence of random series, laws of large numbers, weak convergence of probability measures, central limit theorems, infinitely divisible and stable laws, conditional expectation with respect to sigma algebra, discrete parameter martingales.

Srikanth Krishnan Iyer

References :
• Billingsley, P., Probability and Measure (3rd Ed.), Wiley India, 2008.
• Walsh, J., Knowing the Odds: An Introduction to Probability, AMS, 2012.

Pre-requisites :
• MA 222

MA 365 (AUG) 3:0

Topics in Gaussian Processes

A course in Gaussian processes. At first we shall study basic facts about Gaussian processes - isoperimetric inequality and concentration, comparison inequalities, boundedness and continuity of Gaussian processes, Gaussian series of functions, etc. Later we specialize to smooth Gaussian processes and their nodal sets, in particular expected length and number of nodal sets, persistence probability and other such results from recent papers of many authors.

Manjunath Krishnapur

References :
• A. I. Bogachev, Gaussian Measures, American Mathematical Society, Providence, RI, 1998

Pre-requisites :
• MA 361
MA 381 (AUG) 3:0
Topics in Several Complex Variables II

The aim of this course is to provide an introduction to CR (Cauchy Riemann/Complex Real) geometry, which is broadly the study of the structure(s) inherited by real submanifolds in complex spaces. We will first give a parallel introduction to the fundamental objects of SCV and CR geometry. These include holomorphic functions in several variables, CR manifolds (embedded and abstract) and CR functions. Next, we will cover some examples, results, and techniques from the following range of topics: a) embeddability of abstract CR structures; b) holomorphic extendability of CR functions; c) CR singularities. Wherever possible (and time permitting), we will highlight the connections of this field to other areas of analysis and geometry. For instance, abstract CR structures will be discussed in the broader context of involutive structures on smooth manifolds.

Purvi Gupta

References:

Pre-requisites:
- MA 224 (Complex Analysis)
- Basic familiarity with: differentiable manifolds, tangent and cotangent bundles, and systems of (first order) PDEs.

MA 399 (AUG) 2:0
Seminar on topics in Mathematics

MA 201 (JAN) 7:0
Project
Integrated PhD project

ThirupathiGudi

MA 213 (JAN) 3:1
Algebra II


Radhika Ganapathy

References:
- Lang, S., Algebra (3rd Ed.), Springer, 2002
- Hungerford, Algebra, Graduate Texts in Mathematics 73, Springer Verlag, 1974.
- Galois Theory, Artin, E., University of Notre Dame Press, 1944.

Pre-requisites:
- MA 212
MA 215 (JAN) 3:0

Introduction to Modular Forms

The modular group and its subgroups, the fundamental domain. Modular forms, examples, Eisenstein series, cusp forms. Valence (dimension) formula, Petersson inner product. Hecke operators. L-functions: definition, analytic continuation and functional equation.

Soumya Das

References:
- Iwaniec, H., Topics in Classical Automorphic Forms, Graduate Texts in Mathematics 17, AMS, 1997.
- Diamond, F. and Schurman, J., A First Course in Modular Forms, Graduate Texts in Mathematics no. 228, Springer-Verlag, 2005.

Pre-requisites:
- MA 224

MA 222 (JAN) 3:1

Analysis II


Manjunath Krishnapur

References:

Pre-requisites:
- MA 221

MA 224 (JAN) 3:1

Complex Analysis


Purvi Gupta

References:

Pre-requisites:
- MA 221

MA 229 (JAN) 3:0

Calculus on manifolds

Basics: The inverse function and implicit function theorems. The Riemann integral in higher dimensions, partitions of unity, the change of variables formula. Stokes’ Theorem: Introductory multilinear algebra, differential forms, the exterior derivative. Integration of differential forms, differentiable simplices and
chains, Stokes' Theorem for differentiable chains. Stokes' Theorem for embedded submanifolds in
Euclidean space: motivations and statement, examples and special cases. Differentiable manifolds:
Definitions and examples. Smooth functions on manifolds. The tangent bundle. Immersions, embeddings
and submersions. The implicit function theorem on manifolds.

Ved V Datar

References :
• Spivak, M. Calculus on Manifolds. W.A. Benjamin. co. 1965.

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: Picard's theorems, Grownwall's inequality, Dependence on initial conditions and associated flows. Linear system:The fundamental matrix, stability of
equilibrium points, Phase-plane analysis, Sturm-Liouville theory. Nonlinear system and their
stability: Lyapunov's method, Nonlinear Perturbation of linear systems, Periodic solutions and Poincare-
Bendixson theorem

Nandakumaran A K

References :

Pre-requisites :
• MA 221

MA 278 (JAN) 3:0

Introduction to Dynamical Systems Theory

Linear Stability analysis, attractors, limit cycles, Poincare-Bendixson theorem, relaxation
oscillations. Elements of Bifurcation theory, saddle-node, transcritical, pitchfork and Hopf bifurcations.
Integrability, Hamiltonian systems, Lotka-Volterra equations. Lyapunov functions and direct methods for
stability, dissipative systems, Lorenz systems, chaos and its measures, Lyapunov exponents, strange
attractors, simple maps, period-doubling bifurcations, Feigenbaum constants, fractals.

Thangavelu S

MA 304 (JAN) 3:0

Topics in Harmonic Analysis

Syllabus: Fractional powers of Laplacian $\Delta$ on $\mathbb{R}^n$ and sublaplacian $\mathcal{L}$ on
Extension problem for $\Delta$ and $\mathcal{L}$. Trace Hardy inequality. Hardy's inequality for
conformally invariant fractional powers of $\Delta$ and $\mathcal{L}$. Some applications to PDE and
spectral theory of Schrodinger operators.

Thangavelu S

References :
Pre-requisites:

• Basic Fourier Analysis and Partial Differential Equations.

MA 312 (JAN) 3.0

Commutative Algebra

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

Abhishek Banerjee

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 taquin, 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., Enumerative Combinatorics, volume 2, Cambridge University Press, 2001
• Stanley, R., Lecture notes on Topics in Algebraic Combinatorics.

MA 321 (JAN) 3.0

Analysis III


Narayanan E K

References:

• Evans, L. C., Partial Differential Equations, Univ. of California, Berkeley, 1998.
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.

Subhojoy Gupta

References:
- Spivak M., A comprehensive introduction to differential geometry (Vol. 1) (3rd Ed.), Publish or Perish, Inc., Houston, Texas, 2005

Pre-requisites:
- MA 219, MA 231

MA 363 (JAN) 3:0

Probability in higher dimensions

This course will be aimed at understanding the behavior of random geometric objects in high dimensional spaces such as random vectors, random graphs, random matrices, and random subspaces, as well. Topics will include the concentration of measure phenomenon, non-asymptotic random matrix theory, chaining and Gaussian processes, empirical processes, and some related topics from geometric functional analysis and convex geometry. Towards the latter half of the course, a few applications of the topics covered in the first half will be considered such as community detection, covariance estimation, randomized dimension reduction, and sparse recovery problems.

Thangavelu S

References:

Pre-requisites:
- Graduate level measure theoretic probability will be useful, but not a requirement.
- Students are expected to be familiar with basic probability theory and linear algebra.

MA 380 (JAN) 3:0

Introduction to Complex Dynamics

The dynamics alluded to by the title of the course refers to dynamical systems that arise from iterating a holomorphic self-map of a complex manifold. In this course, the manifolds underlying these dynamical systems will be of complex dimension 1. The foundations of complex dynamics are best introduced in the setting of compact spaces. Iterative dynamical systems on compact Riemann surfaces other than the Riemann sphere – viewed here as the one-point compactification of the complex plane – are relatively simple. We shall study what this means. Thereafter, the focus will shift to rational functions: these are the
holomorphic self-maps of the Riemann sphere. Along the way, some of the local theory of fixed points will be presented. In the case of rational maps, some ergodic-theoretic properties of the orbits under iteration will be studied. The development of the latter will be self-contained. The properties/ theory covered will depend on the time available and on the audience’s interest.

Gautam Bharali

References:

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

Kaushal Verma
**Department of Physics**

The department of Physics offers three post-undergraduate courses: Integrated PhD Physics (I-PhD), PhD Physics, and PhD in Joint Astronomy Programme (JAP).

The I-PhD programme in Physics requires finishing total 64 credits of core and elective courses in the first two years after joining. The elective courses can be chosen across various departments in IISc after consulting faculty mentors. The PhD Physics students can take any of the courses offered in the department after consulting with their PhD supervisor. The students must finish 12 credits.

The JAP PhD students must take a set of core courses (total 15 credits) in the first year of their programme.

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Course No.</th>
<th>Credits</th>
<th>Course title</th>
<th>Nature</th>
<th>Term</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>PH 201</td>
<td>3:0</td>
<td>Classical Mechanics</td>
<td>Core</td>
<td>August</td>
</tr>
<tr>
<td>2</td>
<td>PH 202</td>
<td>3:0</td>
<td>Statistical Mechanics</td>
<td>Core</td>
<td>Jan</td>
</tr>
<tr>
<td>3</td>
<td>PH 203</td>
<td>3:0</td>
<td>Quantum Mechanics I</td>
<td>Core</td>
<td>August</td>
</tr>
<tr>
<td>4</td>
<td>PH 204</td>
<td>3:0</td>
<td>Quantum Mechanics II</td>
<td>Core</td>
<td>Jan</td>
</tr>
<tr>
<td>5</td>
<td>PH 205</td>
<td>3:0</td>
<td>Mathematical Methods of Physics</td>
<td>Core</td>
<td>August</td>
</tr>
<tr>
<td>6</td>
<td>PH 206</td>
<td>3:0</td>
<td>Electromagnetic Theory</td>
<td>Core</td>
<td>Jan</td>
</tr>
<tr>
<td>7</td>
<td>PH 207</td>
<td>1:2</td>
<td>Analog Digital and Microprocessor Electronics</td>
<td>Core</td>
<td>Jan</td>
</tr>
<tr>
<td>8</td>
<td>PH 208</td>
<td>3:0</td>
<td>Condensed Matter Physics-I</td>
<td>Core</td>
<td>Jan</td>
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<tr>
<td>9</td>
<td>PH 211</td>
<td>0:3</td>
<td>General Physics Laboratory</td>
<td>Core</td>
<td>August</td>
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<tr>
<td>10</td>
<td>PH 212</td>
<td>0:3</td>
<td>Experiments in Condensed Matter Physics</td>
<td>Core</td>
<td>Jan</td>
</tr>
<tr>
<td>11</td>
<td>PH 213</td>
<td>0:4</td>
<td>Advanced Experiments in Condensed Matter Physics</td>
<td>Core</td>
<td>August</td>
</tr>
<tr>
<td>12</td>
<td>HE 215</td>
<td>3:0</td>
<td>Nuclear and Particle Physics</td>
<td>Core</td>
<td>August</td>
</tr>
<tr>
<td>13</td>
<td>PH 217</td>
<td>3:0</td>
<td>Fundamentals of Astrophysics</td>
<td>Core</td>
<td>August</td>
</tr>
<tr>
<td>14</td>
<td>PH 231</td>
<td>0:1</td>
<td>Workshop practice</td>
<td>Core</td>
<td>August</td>
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<tr>
<td>15</td>
<td>PH 300</td>
<td>1:0</td>
<td>Seminar Course</td>
<td>Core</td>
<td>August</td>
</tr>
<tr>
<td>16</td>
<td>PH 330</td>
<td>0:3</td>
<td>Advanced Independent Project</td>
<td>Core</td>
<td>August</td>
</tr>
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</table>

**Project:**

<table>
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<tr>
<th>Sl. No</th>
<th>Course No.</th>
<th>Credits</th>
<th>Term</th>
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<tbody>
<tr>
<td>01</td>
<td>PH 250A</td>
<td>0:6</td>
<td>January</td>
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<tr>
<td>02</td>
<td>PH 250B</td>
<td>0:6</td>
<td>May-June</td>
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Scheme of Instruction 2020 - 2021
JAP Core Courses:

<table>
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<tr>
<th>Sl. No</th>
<th>Course No.</th>
<th>Credits</th>
<th>Course title</th>
<th>Nature</th>
<th>Term</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>PH 217</td>
<td>3:0</td>
<td>Fundamental of Astrophysics</td>
<td>Core</td>
<td>Aug</td>
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<tr>
<td>2</td>
<td>PH 362</td>
<td>2:0</td>
<td>Radiative Processes in Astrophysics</td>
<td>Core</td>
<td>Aug</td>
</tr>
<tr>
<td>3</td>
<td>PH 363</td>
<td>2:0</td>
<td>Introduction to Fluid Mechanics and Plasma Physics</td>
<td>Core</td>
<td>Aug</td>
</tr>
<tr>
<td>4</td>
<td>PH 365</td>
<td>3:0</td>
<td>Galaxies and the Interstellar Medium</td>
<td>Core</td>
<td>Jan</td>
</tr>
<tr>
<td>5</td>
<td>PH 371</td>
<td>3:0</td>
<td>General Relativity and Cosmology</td>
<td>Core</td>
<td>Jan</td>
</tr>
<tr>
<td>6</td>
<td>PH 377</td>
<td>0:2</td>
<td>Astronomical Techniques</td>
<td>Core</td>
<td>Jan</td>
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</table>

Elective Courses:

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<tr>
<th>#</th>
<th>Course No.</th>
<th>Credits</th>
<th>Course title</th>
<th>Nature</th>
<th>Term</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>PH 320</td>
<td>3:0</td>
<td>Condensed Matter Physics II</td>
<td>Elective</td>
<td>August</td>
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<tr>
<td>2</td>
<td>PH 322</td>
<td>3:0</td>
<td>Molecular Simulation</td>
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<td>Jan</td>
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<tr>
<td>3</td>
<td>PH 325</td>
<td>3:0</td>
<td>Advanced Statistical Physics</td>
<td>Elective</td>
<td>August</td>
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<tr>
<td>4</td>
<td>PH 333</td>
<td>3:0</td>
<td>Physics of Disordered Systems</td>
<td>Elective</td>
<td>Jan</td>
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<tr>
<td>5</td>
<td>PH 335</td>
<td>3:0</td>
<td>Modern topics in condensed matter</td>
<td>Elective</td>
<td>Jan</td>
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<tr>
<td>6</td>
<td>PH 340</td>
<td>4:0</td>
<td>Quantum Statistical Field Theory</td>
<td>Elective</td>
<td>Jan</td>
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<tr>
<td>7</td>
<td>PH 350</td>
<td>3:0</td>
<td>Physics of Soft Condensed Matter</td>
<td>Elective</td>
<td>Jan</td>
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<tr>
<td>8</td>
<td>PH 351</td>
<td>3:0</td>
<td>Crystal Growth, Thin Films and Characterization</td>
<td>Elective</td>
<td>August</td>
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<tr>
<td>9</td>
<td>PH 352</td>
<td>3:0</td>
<td>Semiconductor Physics and Technology</td>
<td>Elective</td>
<td>Jan</td>
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<tr>
<td>10</td>
<td>PH 353</td>
<td>3:0</td>
<td>Principles of Magnetism in Solids</td>
<td>Elective</td>
<td>Aug</td>
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<tr>
<td>11</td>
<td>PH 354</td>
<td>3:0</td>
<td>Computational Physics</td>
<td>Elective</td>
<td>Jan</td>
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<td>12</td>
<td>PH 359</td>
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<td>Physics at the Nanoscale</td>
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<td>Biological Physics</td>
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<td>Aug</td>
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<td>PH 364</td>
<td>3:0</td>
<td>Topological Phases of Matter (Theory and experiment)</td>
<td>Elective</td>
<td>Jan</td>
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<tr>
<td>PH 366</td>
<td>3:0</td>
<td>Physics of Advanced Optical Materials</td>
<td>Elective</td>
<td>Jan</td>
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</table>

**PH 201 (AUG) 3:0**  
**Classical Mechanics**


*Animesh Kuley*

**References:**

**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:**
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

Prasad Vishnu Bhotla, Victor Suvisesha Muthu D
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

PH 215 (AUG) 3:0
Nuclear and Particle Physics

Sudhir Kumar Vempati
Pre-requisites:

PH 217 (AUG) 3:0
Fundamentals of Astrophysics

Nirupam Roy, Banibrata Mukhopadhyay
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) 1:0
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.

Akshay Singh, Anindya Das

Pre-requisites :
• Seminar course, 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

Sriram Ramaswamy, Subroto Mukerjee

Pre-requisites :
• Chaikin, P.M., and Lubensky, T.C., Principles of Condensed Matter Physics
PH 330 (AUG) 0:3
Advanced Independent Project

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 multicomponent 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 362 (AUG) 2:0
Radiative Processes in Astrophysics

Prateek Sharma

Pre-requisites:

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

Nirupam Roy

References:
- It will be taught by Prof. Arun Mangalam (IIA)

Pre-requisites:

PH 391 (AUG) 3:0
Quantum Mechanics III
Apoorva Patel
PH 395 (AUG) 3:0
Quantum Field Theory I

Aninda Sinha
Pre-requisites:
- PHY 203 Quantum Mechanics I
- PHY 204 Quantum Mechanics II

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.

Justin Raj David
References:

PH 204 (JAN) 3:0
Quantum Mechanics II

Diptiman Sen
References:
PH 206 (JAN) 3:0
Electromagnetic Theory

Prasad Satish Hegde
References:
- Jackson, J.D., Classical Electrodynamics, Third Edn, John Wiley.
- Jackson, J.D., Classical Electrodynamics, Third Edn, John Wiley

PH 207 (JAN) 1:2
Electronics I
Basic diode and transistor circuits, operational amplifier and applications, active filters, voltage regulators, oscillators, digital electronics, logic gates, Boolean algebra, flip-flops, multiplexers, counters, displays, decoders, D/A, A/D. Introduction to microprocessors.

Vibhor Singh
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.

Vijay B Shenoy
References:
- Ashcroft, N.W., and Mermin, N.D., Solid State Physics

PH 212 (JAN) 0:3
Experiments in Condensed Matter
Stirling Engine, Thin film deposition by thermal evaporation technique, Low temperature measurement (using closed cycle helium cryostat), Scanning Tunneling Microscope, Atomic Force Microscope, Franck-Hertz experiment, Laue Pattern of single crystal, Thermogenerator (Peltier and Seebeck effect), Alpha Scattering, Lock-in Amplifier.

Akshay Singh, Anindya Das
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).

Subroto Mukerjee

Pre-requisites:
• 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

Subroto Mukerjee, Arindam Ghosh

PH 316 (JAN) 3:0
Advanced Mathematical Methods

Sachindeo Vaidya

References:

PH 340 (JAN) 3:0
Quantum Statistical Field Theory
Physics

Tanmoy Das

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

Prateek Sharma, Prabal Kumar Maiti

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

Aveek Bid

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

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.
Ambarish Ghosh, Jaydeep Kumar Basu

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

Rajeev Kumar Jain

References:

PH 377 (JAN) 2:0
Astronomical Techniques
Radio: coordinate system, detection principles, resolution and sensitivity, interferometry and aperturesynthesis. IR/Optical/UV: CCD fundamentals, imaging systems, point-spread-function, sensitivity, photometry and spectroscopy, speckle techniques, adaptive optics. X-ray/Gamma-ray astrophysics: detection principles, detectors and imaging systems, resolution and sensitivity, detector response, data analysis methods for spectroscopic and timing studies. Coordinated laboratory / data analysis exercises in each of the three areas.

Nirupam Roy

References:

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

Ananthanarayanan B

Pre-requisites:
PH 398 (JAN) 3:0
General Relativity


Chethan Krishnan

References:
Centre for High Energy Physics

CHEP started a Ph.D. programme from the academic year 1996-97. The minimum qualification for applying is an M.Sc. in Physics, Mathematics or Chemistry, or a B.E./B.Tech. degree. The programme is oriented towards research in theoretical and experimental high energy physics as well as mathematical physics. General research areas include: quantum field theory, the standard model of particle physics and beyond, new particle searches, collider data analysis, detector physics and fabrication, QCD and lattice gauge theories, quantum gravity, string theory and black holes, non-commutative geometry, quantum computation, condensed matter systems in low dimensions. The research interests of individual faculty members can be found in their respective home pages under Personnel. The advertisement, examination, interview procedure, etc. are part of the overall procedure followed by IISc. The interviews for the CHEP programme are conducted by a departmental committee. After admission, basic knowledge of the incoming students in the following subjects is checked: Classical mechanics, Electromagnetic theory, Mathematical physics, Quantum mechanics, Thermodynamics and statistical physics. During the first year, students are expected to fill up gaps in their knowledge, if necessary by solving a set of problems on the subjects.

Course requirements:

<table>
<thead>
<tr>
<th>First semester</th>
<th>Second semester</th>
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<tbody>
<tr>
<td>Quantum Field Theory I 3:0</td>
<td>The Standard Model of Particle Physics 3:0</td>
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<td>Elective E1 (Two) 6:0</td>
<td>Elective E2 (None to Two) 0/3:0/6:0</td>
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<td>Third semester</td>
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</table>

The minimum course credit requirement for the IISc Ph.D. programme is 12. The total course credit requirement for CHEP students can be higher---the list above ranges from 12 to 21 credits (because of the extra electives). The DCC may advise students to take these extra electives depending on their research area. Electives (some electives may not be offered every year):

E1: Nuclear and Particle Physics (3:0),
Quantum Mechanics III (3:0),
Experimental High Energy Physics (3:0),
Advanced Statistical Physics (3:0),
Condensed Matter Physics II (3:0).

E2: Advanced Mathematical Methods in Physics (3:0),
Quantum Field Theory II (3:0),
General Relativity (3:0),
Quantum Statistical Field Theory (3:0),
Quantum Computation (3:0),
String Theory (3:0),
QCD and Collider Physics (3:0).

E3: ADS/CFT as Quantum Gravity (3:0),
String Theory II (3:0).
All the electives may not be offered every year. The students have to choose the electives in consultation with their supervisors. The supervisor may ask the students to take more electives than the list above, even after the Comprehensive Exam, as per his/her needs and interests. There is no provision for skipping courses, but a student may seek exemption from any course by passing a written test at the beginning of the term.

Some of the courses overlap with those of the Physics department. The CHEP specific courses are: Nuclear and Particle Physics, Quantum Mechanics III, Quantum Field Theory I and II, Advanced Mathematical Physics, General Relativity, Quantum Computation, String Theory and II, The Standard Model of Particle Physics, Experimental High Energy Physics, and Collider Physics. The syllabi for these courses appear below.

There will be a Comprehensive Exam, which the students must take as soon as possible after passing the above courses. In any case, they must take the exam before the end of their second year. The exam will test whether the student has sufficient preparation to begin Ph.D. research. Those who fail the exam will be given another attempt after a few months. At the time of joining, each student must find a provisional Faculty Advisor, who may not turn out to be the actual Ph.D. supervisor. The student must select the Ph.D. supervisor by the end of the second semester. Students will be permitted to work with a faculty outside CHEP if their research interests so demand. In such cases, however, they must have a joint supervisor in CHEP. Beginning from the second year, students must present a seminar each year on their work, to acquaint the CHEP faculty with their progress.
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:

HE 391 (AUG) 3:0

Quantum Mechanics III


Apoorva Patel
References:
- (2) Bjorken J.D. and Drell S., Relativistic Quantum Mechanics, McGraw-Hill, 1965.

Pre-requisites:
- Quantum Mechanics I (PH 201) and Quantum Mechanics II (PH 203), or equivalent

HE 395 (AUG) 3:0
Quantum Field Theory I

Aninda Sinha

References:
- Zee A., Quantum Field Theory in a Nutshell (Second edition), Princeton University Press, 2010
- Srednicki M., Quantum Field Theory, Cambridge University Press, 2007
- Ryder L.H., Quantum Field Theory (Second edition), Cambridge University Press, 1996

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

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 392 (JAN) 3:0
Standard Model of Particle Physics

BiplobBhattacherjee
References:

Pre-requisites:
- Quantum Field Theory I

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.

Pre-requisites:
- HE 395 Quantum Field Theory I

HE 398 (JAN) 3:0
General Relativity

Chethan Krishnan

References:

Scheme of Instruction 2020 - 2021
Preface

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

- E0 Computer Science and Engineering
- E1 Intelligent Systems and Automation
- E2 Communication Systems
- E3 Electronic Devices, Circuits and Technology
- E4 Power and Energy Systems
- E5 High Voltage and Insulation Engineering
- E6 Power Electronics and Drives
- E7 Photonic Devices, Circuits and Systems
- E8 Electromagnetic, Microwaves and Antennas
- E9 Signal Processing, Acoustics and Bioengineering

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

- M Tech in Electrical Engineering (EE)
- M Tech in Communication and Networks (ECE)
- M Tech in Computer Science and Engineering (CSA)
- M Tech in Electronics Systems Engineering (ESE)
- M Tech in Artificial Intelligence (CSA, ECE, EE, ESE)
- M Tech in Signal Processing (EE and ECE)
- M Tech in Microelectronics and VLSI Design (ECE and ESE)

The dissertation projects in the above M Tech. programs will be numbered as EE 299, CN 299, CS 299, ES 299, Ai 299, SP 299, and MV 299, respectively.

We wish all the students a lively and an intellectually rewarding experience in the Division of EECS at the Indian Institute of Science.

Prof. Y Narahari
Dean, Division of EECS
# Department of Computer Science and Automation
## October – January 2020

### POOL COURSES

<table>
<thead>
<tr>
<th>Course code</th>
<th>Title</th>
<th>Credits</th>
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<td>Theorist's Toolkit</td>
<td>3:1</td>
<td>A</td>
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<tr>
<td>E0 224</td>
<td>Computational Complexity Theory</td>
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<td>A</td>
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<td>Design and Analysis of Algorithms</td>
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<td>E0 226</td>
<td>Linear Algebra and Probability</td>
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<td>C</td>
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<tr>
<td>E0 230</td>
<td>Computational Methods of Optimization</td>
<td>3:1</td>
<td>C</td>
<td>Soft core</td>
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<td>E0 235</td>
<td>Cryptography</td>
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<td>A</td>
<td>Soft core</td>
</tr>
<tr>
<td>E0 243</td>
<td>High Performance Computer Architecture</td>
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<td>B</td>
<td>Soft core</td>
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<td>E0 254</td>
<td>Network and Distributed Systems Security</td>
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<td>E0 256</td>
<td>Theory and Practice of Computer Systems Security</td>
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<td>E0 267</td>
<td>Soft Computing</td>
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<tr>
<td>E0 271</td>
<td>Graphics and Visualization</td>
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#### Pool Course: October – January – 2020

**Pool A**

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<th>Course Number</th>
<th>Title</th>
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<tbody>
<tr>
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<td>Theorist’s Toolkit</td>
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<tr>
<td>E0 224</td>
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<td>E0 225</td>
<td>Design and Analysis of Algorithms</td>
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<td>E0 235</td>
<td>Cryptography</td>
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**Pool B**

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<td>Network and Distributed Systems Security</td>
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</tr>
<tr>
<td>E0 256</td>
<td>Theory and Practice of Computer Systems Security</td>
<td>3:1</td>
</tr>
<tr>
<td>E0 271</td>
<td>Graphics and Visualization</td>
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**Pool C**

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<td>Computational Methods of Optimization</td>
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<td>CP 214</td>
<td>Foundations of Robotics</td>
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## Scheme of Instruction 2020 - 2021

### February – May 2021

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<td>E0 207</td>
<td>Computational Topology: Theory and Applications</td>
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<td>Computational Geometry</td>
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<td>E0 209</td>
<td>Principles of Distributed Software</td>
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<tr>
<td>E0 210</td>
<td>Dynamic Program Analysis: Algorithms and Tools</td>
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<td>E0 234</td>
<td>Introduction to Randomized Algorithms</td>
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<td>E0 238</td>
<td>Intelligent Agents</td>
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<td>E0 248</td>
<td>Theoretical Foundations of Cryptography</td>
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<td>E0 253</td>
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<td>E0 255</td>
<td>Compiler Design</td>
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**Pool Course:** February – May: 2021

**Pool A**

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<td>Computational Topology: Theory and Applications</td>
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<td>E0 208</td>
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<td>Principles of Distributed Software</td>
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<td>E0 210</td>
<td>Dynamic Program Analysis: Algorithms and Tools</td>
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<td>Operating Systems</td>
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<td>E0 270</td>
<td>Machine Learning</td>
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<td>E1 277</td>
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<tr>
<td>E1 254</td>
<td>Game Theory</td>
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</table>
**Dept of Computer Science and Automation**

**E0 206 (AUG) 3:1**

**Theorist’s Toolkit**

Motivation and objectives of the course: This course is intended to equip a student interested in studying theoretical computer science with some of the fundamental tools commonly used in this area. Tentative Syllabus: The topics covered are likely to be a subset of the following.

a. Probabilistic methods: Linearity of expectations, alterations, second moment, Lovasz local lemma, martingales, random graphs, Johnson-Lindenstrauss lemma, etc.

b. Streaming algorithms: Hash functions, pairwise independence, heavy hitters in data stream, p-stable distributions, counting distinct elements, etc.

c. Information theory: Shearer’s Lemma, entropy and compression, Pinsker’s lemma, KL-divergence, application in bandits and streaming algorithms, etc.

d. Linear algebra based algorithms: Courant-Fischer Theorem, SVD, Cheeger’s Inequality, expanders, etc.

e. Discrete Fourier analysis: Boolean function and Fourier expansion, applications in property testing, etc.

f. Multiplicative weights update: Hedge algorithm, applications in packing/covering LPs, online convex optimization, etc.

g. Combinatorial optimization: Farkas lemma, matroids, total unimodularity, total dual integrality, etc.

Anand Louis, Arindam Khan

**References:**

- Various surveys and lecture notes.

**Pre-requisites:**

- Students should have completed or also be registered for E0 225 (Design and Analysis of Algorithms).

**E0 224 (AUG) 3:1**

**Computational Complexity Theory**

Computational complexity theory is the fundamental subject of classifying computational problems based on their `complexities`. In this context, ‘complexity’ of a problem is a measure of the amount of resource (time/space/random bits, or queries) used by the best possible algorithm that solves the problem. The aim of this course is to give a basic introduction to this field. Starting with the basic definitions and properties, we intend to cover some of the classical results and proof techniques of complexity theory. Introduction to basic complexity classes; notion of ‘reductions’ and ‘completeness’; time hierarchy theorem & Ladner’s theorem; space bounded computation; polynomial time hierarchy; Boolean circuit complexity; complexity of randomized computation; interactive proofs; complexity of counting.

Chandan Saha

**References:**

- Lecture notes of similar courses as and when required.

**Pre-requisites:**

- Basic familiarity with undergraduate level theory of computation and data structures & algorithms would be helpful.
- More importantly, some mathematical maturity with an inclination towards theoretical computer science.
E0 225 (AUG) 3:1
Design and Analysis of Algorithms

Siddharth Barman, Rahul Saladi

E0 226 (AUG) 3:1
Linear Algebra and Probability

Gugan Thoppe, Shirish Krishnaji Shevade

References :

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

Chiranjib Bhattacharyya

References :

E0 235 (AUG) 3:1
Cryptography

Arpita Patra, Chaya Ganesh
E0 243 (AUG) 3:1

Computer architecture

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

Govindarajan R, Arkaprava Basu

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

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; 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 Detection; Firewalls.

Ramesh Chandra Hansdah

References:
• Current Literature.

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

Vinod Ganapathy

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 302 (AUG) 3:1
Topics in Software Engineering
Course objective: Study and design of machine learning techniques to improve software engineering. Motivation: Machine learning has become an effective technique for making sense of large datasets to glean actionable insights. Large software repositories such as open source gits, smartphone app stores and student submissions in MOOCs courses contain a wealth of information. The goal of this course is to study and design state-of-the-art machine learning techniques to improve software engineering using the large amount of code available. Syllabus: Machine learning models for program analysis, automated program repair, program synthesis, mining software repositories, representation and deep learning for
software engineering, programming language processing.

Shirish Krishnaji Shevade, Aditya Sunil Kanade

**References:**
- Research papers

**Pre-requisites:**
- Background in programming
- Data mining or machine learning course in CSA

**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.

**Pre-requisites:**
- Basic familiarity with probability theory, linear algebra, and graph theory and combinatorics.

**E0 334 (AUG) 3:1**

**Deep Learning for Natural Language Processing**


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 361 (AUG) 3:1
Topics in Database Systems

Jayant R Haritsa

E1 396 (AUG) 3:1
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.

Gugan Thoppe, Shalabh Bhatnagar

References:
• Relevant research papers

Pre-requisites:
• A basic course on probability theory and stochastic processes

E0 202 (JAN) 3:1
Automated Software Engineering with Machine Learning
Engineering high-quality software requires mastering advanced programming concepts, and dealing with large and complex code. This course will introduce program analysis and machine/deep learning techniques to help developers in this quest. It will focus on concurrency and security analysis of smartphone and web applications. There is growing realization in the software community that we can learn useful program properties from large codebases by treating code as data, and augmenting program analysis with machine learning. This course will introduce machine/deep learning techniques to build probabilistic models of source code, and discuss how they can be used to solve novel problems in software engineering. Programming Language Processing: tokenization, parsing and semantic analysis, graph representations, syntactic transformations. Smartphone and Web Programming: multi-threading, asynchronous event-handling, permissions. Program Analysis: static and dynamic analysis of concurrent programs, model checking, information flow analysis for security, random testing. Probabilistic Models of Source Code: program embeddings, probabilistic grammars, statistical language models, structural models. Applications of Machine Learning (e.g., code completion, software testing and debugging).

Aditya Sunil Kanade

References:
• Research papers

E0 205 (JAN) 3:1
Mathematical Logic and Theorem Proving
Motivation and objectives of the course: This course is about mathematical logic with a focus on automated reasoning techniques that are useful in reasoning about programs. In the first part of the course we cover Propositional and First-Order logic and some of the classical results like sound and complete proof systems, compactness, and decidability of the satisfiability/validity problems. In the second part we focus on decision procedures for various theories that arise while reasoning about assertions in programs.

Syllabus: Zeroth-Order/Propositional Logic: - Proofs in arithmetic - Propositional logic, proof systems - Decision procedure, completeness and compactness First-Order Logic: - Proof systems - Undecidability - Completeness and compactness Theories and Decision Procedures: - Equality and Uninterpreted Functions (EUF) - Linear Arithmetic - Array logics - Nelson-Oppen combination

Kamal Lodaya, Deepak DSouza

References:
• First-order Logic and automated theorem proving, Melvin Fitting, Springer-Verlag, 1990.
• Logic for Computer Science -- Foundations for Automatic Theorem Proving, Jean H. Gallier.
• An Introduction to Logic, Madhavan Mukund and S P Suresh, Lecture Notes, Chennai Mathematical Institute (2011).

Pre-requisites:
• None.

E0 207 (JAN) 3:1
Computational Topology: Theory and Applications

Gugan Thoppe, Vijay Natarajan

References:
• Current Literature

Pre-requisites:
• Undergraduate Probability and Linear Algebra, E0 225: Design and Analysis of Algorithms

E0 208 (JAN) 3:1
Computational Geometry
Motivation and objective of the course: Computational Geometry is an area of computer science that looks at the computational aspects of geometric problems such as running time of an algorithm, space occupied by a data structure, design of polynomial time approximation algorithms. This area has been well studied.
over the last four decades and has found applications in computer graphics, computer-aided design, geographic information systems, robotics, etc. This course will focus on the theoretical aspects of algorithms and data structures for various geometric problems. Syllabus: The list of topics covered in this course include a. Convex hulls: 2-D and higher dimensional convex hulls, output sensitive algorithms, randomized incremental construction b. Intersection detection: Segment intersection, plane sweep technique. c. Geometric data structures for range searching and point location: Segment and interval trees, range trees, kd-tree, persistence. d. Proximity problems: Voronoi diagram, Delaunay triangulation, well separated pair decomposition, locality sensitive hashing. e. Arrangements: Arrangements of lines and hyperplanes, sweep-line and incremental algorithms, lower envelopes, levels, zones. f. Geometric sampling: Random sampling and epsilon-nets, epsilon-approximation and discrepancy, coresets. g. Geometric optimization: Linear programming, geometric set cover, geometric independent set, clustering.

Rahul Saladi, Sathish Govindarajan

References:
• Lecture notes on Computational Geometry by David Mount: https://www.cs.umd.edu/class/spring2012/cmsc754/Lects/cmsc754-lects.pdf

Pre-requisites:
• E0 225: Design and Analysis of Algorithms

EO 209 (JAN) 3:1

Principles of Distributed Software

Motivation and objectives of the course: Development of distributed software applications is a very important activity, accelerated in recent years by the increasing predominance of cloud computing. The typical requirements from a modern day distributed application are continuous availability even in the presence of software and hardware faults, ability to scale up or down on-the-fly based on input load (i.e., elasticity), ease of development and maintenance, and ease of continuous integration and deployment. This course will introduce the principles and programming models and frameworks for distributed applications that help meet these requirements. It will also cover representative modern languages and technologies that are used to develop and deploy such applications. Syllabus: Main features of cloud applications, such as availability, fault tolerance, elasticity, and microservices. The challenges in building cloud applications. Introduction to different types of concurrent and distributed programming models. Introduction to actors -- a message-driven programming model that enables large scale concurrency, distribution, and fault tolerance. Programming actor-based systems using the Akka toolkit. Achieving availability and elasticity by distributing the application over multiple nodes using Akka Cluster. Using Kubernetes to deploy, scale, and monitor distributed applications. Consistency of data in distributed programs, eventual consistency, and implementing these features using Conflict-free Replicated Data Types in Akka. Practical application of these principles in a substantial course project.

Raghavan K V

References:
• Designing Distributed Systems, by Brendan Burns, O'Reilly, 2018
• Online documentation for Akka and Kubernetes
• Selected research papers
• https://azure.microsoft.com/en-us/resources/designing-distributed-systems/ https://www.amazon.in/Designing-Distributed-Systems-Patterns-Paradigms-Patterns-ebook/dp/B079YTM4FC

Pre-requisites:
• Under-graduate level data structures and algorithms. Programming experience required, preferably in Java.
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.

Introduction to Randomized Algorithms

Motivation and objectives of the course: The use of randomness in algorithm design is an extremely powerful paradigm. Often, it makes algorithm design (and analysis) easier; however, there are some problems for which we only know randomized algorithms and no deterministic algorithms. Furthermore, depending on the model of computation, randomization is often essential — it provably does better than all deterministic algorithms. In this course, we will introduce the basic techniques of designing randomized algorithms although at times we will dive into state-of-the-art topics. Students are expected to have taken an introductory course in algorithm design and analysis, and some familiarity with probability, although not essential, is desirable.

Syllabus: Basics of probability, events, discrete random variables, expectation, moments, deviations, Chernoff and Hoefding bounds, balls and bins, random graphs, probabilistic methods, Markov chains and random walk, Monte Carlo method, coupling, martingales, sample complexity, VC dimension, Rademacher complexity, balanced allocation, power of two choices, cuckoo hashing, information and entropy, online algorithms, random-order model, streaming algorithms.

Siddharth Barman, Arindam Khan

References :
• Probability and Computing" by Mitzenmacher and Upfal
• Randomized Algorithms" by Motwani and Raghavan.

Pre-requisites :
• E0 225 (Design and Analysis of Algorithms) and E0 226 (Linear Algebra and Probability).

Intelligent Agents

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

References:

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 253 (JAN) 3:1
Operating Systems

References:

Vinod Ganapathy, ArkapravaBasu

References:

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:
Govindarajan R, Uday Kumar Reddy B

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
Fundamental Issues in Distributed Systems, Distributed System Models and Architectures; Classification of Failures in Distributed Systems, Basic Techniques for Handling Faults in Distributed Systems; Logical Clocks and Virtual Time; Physical Clocks and Clock Synchronization Algorithms; Security Issues in Clock Synchronization; Secure RPC and Group Communication; Group Membership Protocols and Security Issues in Group Membership Problems; Naming Service and Security Issues in Naming Service; Distributed Mutual Exclusion and Coordination Algorithms; Leader Election; Global State, Termination and Distributed Deadlock Detection Algorithms; Distributed Scheduling and Load Balancing; Distributed File Systems and Distributed Shared Memory; Secure Distributed File Systems; Distributed Commit and Recovery Protocols; Security Issues in Commit Protocols; Checkpointing and Recovery Protocols; Secure Checkpointing; Fault-Tolerant Systems, Tolerating Crash and Omission Failures; Implications of Security Issues in Distributed Consensus and Agreement Protocols; Replicated Data Management; Self-Stabilizing Systems; Design Issues in Specialized Distributed Systems.

Ramesh Chandra Hansdah

References:
- Current Literature

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

E0 270 (JAN) 3:1
Machine Learning

Ambedkar Dukkipati, Chiranjib Bhattacharyya

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 309 (JAN) 3:1
Topics in complexity theory
The theme of this course in the Jan-Apr 2015 semester is arithmetic circuit complexity. Arithmetic circuits are algebraic analogue of boolean circuits that naturally compute multivariate polynomials. The quest for a thorough understanding of the power and limitation of the model of arithmetic circuits (and its connection to boolean circuits) has lead researchers to several intriguing structural, lower bound and algorithmic results. These results have bolstered our knowledge by providing crucial insights into the nature of arithmetic circuits. Still, many of the fundamental questions/problems on arithmetic circuits have remained open till date. The aim of this course is to provide an introduction to this area of computational complexity theory. We plan to discuss several classical and contemporary results and learn about a wealth of mathematical (particularly, algebraic and combinatorial) techniques that form the heart of this subject.

Chandan Saha

References:
• Current literature on Arithmetic circuit complexity.

Pre-requisites:
• Familiarity with basic abstract algebra, linear algebra, probability theory and algorithms will be helpful. More importantly, we expect some mathematical maturity with an inclination towards theoretical computer science.

E0 313 (JAN) 3:1
Theory of convex optimization and sampling
Motivation and objectives of the course: This course is intended to teach students in theoretical computer science and related areas about the theory of convex optimization. Our goal is that at the end of the course, students should know some of the common algorithmic techniques used for optimizing convex functions and sampling from convex bodies. Tentative Syllabus: The topics covered are likely to be a subset of the following. a. Introduction to Gradient descent and cousins: Basics of convex functions, gradient descent, accelerated gradient descent, stochastic gradient descent, mirror descent and other variants. b. Cutting plane methods: Center of gravity, Ellipsoid algorithm, recent breakthroughs on improved running times. c. Interior point methods: Newton’s method, theory of self-concordant functions, polynomial time algorithm for linear programming, recent breakthroughs on improved running times. d. Sampling from convex bodies: Basics of Markov Chains, Isoperimetric inequalities, Ball walk, Dikin walk, Hamiltonian Monte Carlo. e. Connections to combinatorial optimization: Graph sparsification, Laplacian system solvers, faster algorithms for max flow.

Anand Louis
References:
- We will be teaching the material from multiple courses/books. Some of them are the following.

Pre-requisites:
- E0 225 (Design and Analysis of Algorithms)

E0 314 (JAN) 3:1

Proof Systems in Cryptography

The course is intended to introduce cryptographic proof systems and applications to students studying cryptography. Syllabus: The tentative topics that will be covered:

* Interactive proofs: Class IP, IP=PSpace Sumcheck protocol, doubly efficient proofs Delegating computation, interactive proofs for muggles Zero-knowledge (ZK) proofs
* Foundations of ZK: ZK for NP, motivation and definitions
* Round complexity, Non-black-box Zero-knowledge
* Sequential and Parallel composition Limitations and lower bounds, Witness indistinguishability
* More ZK: Honest verifier zero-knowledge
* Malicious verifier zero-knowledge, proof of knowledge, zero-knowledge arguments
* Sigma protocols, Non-interactive ZK, Groth-Sahai proof system
* MPC and zero-knowledge, MPC-in-the head

SNARKs (Succinct Non-interactive Arguments of Knowledge): PCP, Succinct arguments, separation from falsifiable assumptions
* Preprocessing SNARKs with trusted setup
* SNARKs from linear PCP
* Polynomial commitments, universal updatable SNARK
* Holographic proofs

Interactive Oracle Proof (IOP): Model and definitions

Applications of IOP in delegation of computation

Transparent SNARKs

Recent developments: Confidential transactions, Anonymous cryptocurrency like ZCash

Recursive composition theorem for SNARK, Proof-carrying data Applications in succinct blockchain, Decentralized private computation, Research directions

Arpita Patra, Chaya Ganesh

References:
- There will be multiple sources. Since this is an advanced course, references for most of the material will be research papers and surveys.
- Foundations of Cryptography, Parts I and II, Oded Goldreich
- Computational Complexity, Barak and Arora
- Surveys by Oded Goldreich on doubly efficient proofs and PCP

Pre-requisites:
- Algorithms, Intro to crypto

E0 320 (JAN) 3:1

Topics in Graph Theory

Minors: Introduction - properties which causes dense minors in graphs: average degree, girth, Wagner's characterisation of graphs without K5 minors.

Tree Decompositions: treewidth, pathwidth, upper and lower bounds for treewidth, relation of treewidth and minors, influence on algorithmic graph problems.

Hadwiger's conjecture - its relation with the four colour theorem, related work.

Sunil Chandran L

References:
- Graph Theory (Chapters 8 and 12), Reinhard Diestel, Springer, 2000.
- Current Literature
E0 343 (JAN) 3:1
**Topics in Computer Architecture**


**Arkaprava Basu**

**Pre-requisites :**

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
- Prior consent of instructor(s)

E1 254 (JAN) 3:1
**Game Theory**


**Siddharth Barman, Narahari Y**
E1 277 (JAN) 3:1
Reinforcement Learning


Gugan Thoppe, Shalabh Bhatnagar

EP 299 (JAN) 0:24
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.

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 gives the students the option to graduate with one of 5 “Minors”:

(i) Minor in Integrated Circuits & Systems,
(ii) Minor in Photonics,
(iii) Minor in Radio-Frequency Systems
(iv) Minor in Signal Processing
(v) Minor in Artificial Intelligence

(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 Minor area.

(d) This basket of courses is further divided into two or three pools, Pool X, Pool Y and Pool Z (only for Minor in Artificial Intelligence), and a student is required to take a total of 3 courses from all pools combined with

(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,
(iii) at least one course from each of the three pools X, Y, and Z, in the case of a Minor in Artificial Intelligence.

(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></th>
<th>4 courses</th>
<th>9 units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Core</td>
<td>4 courses</td>
<td>12 units</td>
</tr>
<tr>
<td>Soft Core</td>
<td>3 courses</td>
<td>9 units</td>
</tr>
<tr>
<td>Electives</td>
<td>2 courses</td>
<td>6 units</td>
</tr>
<tr>
<td>Minor or Electives</td>
<td>3 courses</td>
<td>9 units</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>36 units</strong></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 205 (AUG) 3:0 Error-Control Coding</td>
</tr>
<tr>
<td>E2 223 (AUG) 3:0 Communication Protocols</td>
</tr>
<tr>
<td>E2 242 (JAN) 3:0 Multiuser Detection</td>
</tr>
<tr>
<td>E2 204 (JAN) 3:0 Stochastic Processes and Queueing Theory</td>
</tr>
<tr>
<td>E2 203 (JAN) 3:0 Wireless Communication</td>
</tr>
<tr>
<td>E2 241 (JAN) 3:0 Wireless Networks</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pool B (in no particular order)</th>
</tr>
</thead>
<tbody>
<tr>
<td>E0 259 (AUG) 3:1 Data Analytics</td>
</tr>
<tr>
<td>E0 251 (AUG) 3:1 Data Structures &amp; Algorithms</td>
</tr>
<tr>
<td>E1 251 (AUG) 3:0 Linear and Nonlinear Optimization</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>E1 254 (AUG/JAN) 3:1 Game Theory</td>
</tr>
<tr>
<td>E9 211 (JAN) 3:0 Adaptive Signal Processing</td>
</tr>
<tr>
<td>E7 221 (JAN) 2:1 Fiber – Optic Communication</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>
</tr>
</thead>
<tbody>
<tr>
<td>NE 205 (AUG) 3:0 Semiconductor Devices and Integrated Circuit Technology</td>
</tr>
<tr>
<td>E3 238 (AUG) 2:1 Analog VLSI Circuits</td>
</tr>
<tr>
<td>E0 284 (AUG) 2:1 Digital VLSI Circuits</td>
</tr>
<tr>
<td>E7 211 (JAN) Photonics Integrated Circuits</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pool Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>E3 237 (JAN) 3:0 Integrated Circuits for Wireless Communication</td>
</tr>
<tr>
<td>E8 262 (JAN) 3:0 CAD for High Speed Chip-Package Systems</td>
</tr>
</tbody>
</table>

Scheme of Instruction 2020 - 2021
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>
</tr>
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<tbody>
<tr>
<td>NE 213/E7 213 (AUG) 3:0 Introduction to Photonics</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Pool Y</th>
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</thead>
<tbody>
<tr>
<td>E7 211 (JAN) 3:0 Photonics Integrated Circuits</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>
</tr>
</thead>
<tbody>
<tr>
<td>E8 242 (JAN) 2:1 Radio Frequency Integrated Circuits and Systems</td>
</tr>
<tr>
<td>E3 237 (JAN) 3:0 Integrated Circuits for Wireless Communication</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pool Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>E8 202 (AUG) 2:1 Computational Electromagnetics</td>
</tr>
<tr>
<td>E8 262 (JAN) 3:0 CAD for High Speed Chip-Package Systems</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>
</tr>
</thead>
<tbody>
<tr>
<td>E9 202 (JAN) 3:0 Advanced Digital Signal Processing</td>
</tr>
<tr>
<td>E9 211 (JAN) 3:0 Adaptive Signal Processing</td>
</tr>
<tr>
<td>E9 212 (JAN) 3:0 Spectrum Analysis</td>
</tr>
<tr>
<td>E9 213 (JAN) 3:0 Time-Frequency Analysis</td>
</tr>
<tr>
<td>E9 221 (AUG) 3:0 Signal Quantization and Compression</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pool Y</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1 213 (JAN) 3:1 Pattern Recognition and Neural Networks</td>
</tr>
<tr>
<td>E1 216 (JAN) 3:1 Computer Vision</td>
</tr>
<tr>
<td>E9 203 (JAN) 3:0 Compressed Sensing and Sparse Signal Processing</td>
</tr>
<tr>
<td>E9 262 (JAN) 3:0 Stochastic Models for Language, Speech and Audio</td>
</tr>
<tr>
<td>E9 231 (JAN) 3:0 MIMO Signal Processing</td>
</tr>
<tr>
<td>E9 241 (AUG) 2:1 Digital Image Processing</td>
</tr>
</tbody>
</table>
E9 252 (AUG) 3:0 Mathematical Methods and Techniques in Signal Processing
E9 261 (AUG) 3:1 Speech Information Processing

E. Minor in Artificial Intelligence

Requirements:
- Any 3 of the courses listed below under Pools X, Y & Z
- One course from each pool will qualify a student for a “Minor in Artificial Intelligence”

<table>
<thead>
<tr>
<th>Pool X</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>E1 213 (JAN) 3:1 Pattern Recognition and Neural Networks</td>
<td></td>
</tr>
<tr>
<td>E0 270 (JAN) 3:1 Machine Learning</td>
<td></td>
</tr>
<tr>
<td>E2 236 (JAN) 3:1 Foundations of Machine Learning</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pool Y</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>E0 230 (AUG) 3:1 Computational Methods of Optimization</td>
<td></td>
</tr>
<tr>
<td>E0 265 (JAN) 3:1 Convex Optimization and Applications</td>
<td></td>
</tr>
<tr>
<td>E0 299 (AUG) 3:1 Computational Linear Algebra</td>
<td></td>
</tr>
<tr>
<td>E0 251 (AUG) 3:1 Data Structures and Algorithms</td>
<td></td>
</tr>
<tr>
<td>E1 245 (AUG) 3:0 Online Prediction and Learning</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pool Z</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>E0 251 (AUG) 3:1 Data Analytics</td>
<td></td>
</tr>
<tr>
<td>E0 268 (JAN) 3:1 Practical Data Science</td>
<td></td>
</tr>
<tr>
<td>E1 246 (JAN) 3:1 Natural Language Understanding</td>
<td></td>
</tr>
<tr>
<td>E0 334 (AUG) 3:1 Deep Learning for NLP</td>
<td></td>
</tr>
<tr>
<td>E9 205 (AUG) 3:1 Machine Learning for SP</td>
<td></td>
</tr>
<tr>
<td>DS 222 (AUG) 3:1 ML for Large Data Sets</td>
<td></td>
</tr>
<tr>
<td>DS 265 3:1 (JAN) Deep Learning for Computer Vision</td>
<td></td>
</tr>
<tr>
<td>E0 306 (JAN) 3:1 Deep Learning: Theory and Practice</td>
<td></td>
</tr>
<tr>
<td>E9 253 (JAN) 3:0 Neural Networks and Learning Systems</td>
<td></td>
</tr>
</tbody>
</table>

Project 28 Credits
CN 299 0:28 Dissertation Project
Electives: The balance of credits to make up the minimum of 64 credits required for completing the M.Tech. Programme (all at 200 level or higher) from within/outside the department to be taken with the approval of the Faculty advisor/DCC.
Departments of Electrical Engineering and Electrical Communication Engineering  
MTech Degree in Signal Processing  

(Duration 2 years)  

**COURSE STRUCTURE:** 64 Credits (36 Credits course work + 28 Credits project)  

<table>
<thead>
<tr>
<th>Hard Core (12 Credits) (All courses compulsory)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan</td>
<td>E1 244</td>
<td>3:0</td>
</tr>
<tr>
<td>Aug</td>
<td>E1 251</td>
<td>3:0</td>
</tr>
<tr>
<td>Aug</td>
<td>E2 202</td>
<td>3:0</td>
</tr>
<tr>
<td>Aug</td>
<td>E2 212</td>
<td>3:0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Soft Core (Minimum of 12 Credits)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan</td>
<td>E1 213</td>
<td>3:1</td>
</tr>
<tr>
<td>Jan</td>
<td>E1 216</td>
<td>3:1</td>
</tr>
<tr>
<td>Aug</td>
<td>E2 211</td>
<td>3:0</td>
</tr>
<tr>
<td>Aug</td>
<td>E9 211</td>
<td>3:0</td>
</tr>
<tr>
<td>Jan</td>
<td>E9 213</td>
<td>3:0</td>
</tr>
<tr>
<td>Aug</td>
<td>E9 221</td>
<td>3:0</td>
</tr>
<tr>
<td>Jan</td>
<td>E9 231</td>
<td>3:0</td>
</tr>
<tr>
<td>Aug</td>
<td>E9 241</td>
<td>2:1</td>
</tr>
<tr>
<td>Jan</td>
<td>E9 261</td>
<td>3:1</td>
</tr>
<tr>
<td>Aug</td>
<td>E9 291</td>
<td>2:1</td>
</tr>
</tbody>
</table>

Project: 28 Credits  
**SP 299**  0:28  Dissertation Project  

Electives: The balance of 12 credits to make up the minimum of 64 credits required to complete the MTech degree must be obtained through electives (all at 200 level or higher) from within/outside the EE and ECE departments, taken with the approval of the Faculty advisor/DCC.
# Departments of Electronic Systems Engineering and Electrical Communication Engineering

**MTech Microelectronics and VLSI Design**

<table>
<thead>
<tr>
<th>Duration: 2 Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Credits: 64</td>
</tr>
</tbody>
</table>

## Core Courses: 18 credits, mandatory for all students.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Credits</th>
<th>Semester</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>E0 284</td>
<td>2:1</td>
<td>Aug</td>
<td>Digital VLSI Circuit</td>
</tr>
<tr>
<td>E3 200</td>
<td>1:2</td>
<td>Jan</td>
<td>Microelectronics Lab</td>
</tr>
<tr>
<td>E3 220</td>
<td>3:0</td>
<td>Aug</td>
<td>Foundations of Nanoelectronics Devices</td>
</tr>
<tr>
<td>E3 231</td>
<td>2:1</td>
<td>Jan</td>
<td>Digital Systems Design with FPGAs</td>
</tr>
<tr>
<td>E3 238</td>
<td>2:1</td>
<td>Aug</td>
<td>Analog VLSI Circuits</td>
</tr>
<tr>
<td>E3 282</td>
<td>3:0</td>
<td>Jan</td>
<td>Basics of Semiconductor Devices and Technology</td>
</tr>
</tbody>
</table>

## Electives: 18 credits (all at 200 level or higher).

1. Students can choose any course from the offered list across the institute. Following courses, listed in the Scheme of Instructions, are merely suggestions.
2. Crediting two course having similar syllabus/content is strictly discouraged.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Credits</th>
<th>Semester</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1 201</td>
<td>2:1</td>
<td>Jan</td>
<td>Hardware Acceleration and Optimization for Machine Learning</td>
</tr>
<tr>
<td>E3 225</td>
<td>3:0</td>
<td>Aug</td>
<td>Art of Compact Modelling</td>
</tr>
<tr>
<td>E3 237</td>
<td>3:0</td>
<td>Jan</td>
<td>Integrated Circuits for Wireless Communication</td>
</tr>
<tr>
<td>E3 245</td>
<td>2:1</td>
<td>Aug</td>
<td>Processor System Design</td>
</tr>
<tr>
<td>E3 271</td>
<td>1:2</td>
<td>Jan</td>
<td>Reliability of Nanoscale Circuits and Systems</td>
</tr>
<tr>
<td>E3 274</td>
<td>1:2</td>
<td>Jan</td>
<td>Design of Power Semiconductor Devices</td>
</tr>
<tr>
<td>E3 275</td>
<td>2:1</td>
<td>Jan</td>
<td>Physics and Design of Transistors</td>
</tr>
<tr>
<td>E3 280</td>
<td>3:0</td>
<td>Jan</td>
<td>Carrier Transport in Nanoelectronics Devices</td>
</tr>
<tr>
<td>E3 301</td>
<td>3:0</td>
<td>Jan</td>
<td>Special topics in Nanoelectronics</td>
</tr>
<tr>
<td>E7 211</td>
<td>2:1</td>
<td>Jan</td>
<td>Photonic Integrated Circuits</td>
</tr>
<tr>
<td>E7 214</td>
<td>3:0</td>
<td>Jan</td>
<td>Optoelectronic Devices</td>
</tr>
<tr>
<td>E8 202</td>
<td>2:1</td>
<td>Aug</td>
<td>Computational Electromagnetics</td>
</tr>
<tr>
<td>E8 242</td>
<td>2:1</td>
<td>Jan</td>
<td>RF IC and Systems</td>
</tr>
<tr>
<td>E8 262</td>
<td>3:0</td>
<td>Jan</td>
<td>CAD for High Speed Chip-Package-Systems</td>
</tr>
<tr>
<td>NE 203</td>
<td>3:0</td>
<td>Aug</td>
<td>Advanced Micro and Nano Fabrication Technology and Process</td>
</tr>
<tr>
<td>NE 205</td>
<td>3:0</td>
<td>Aug</td>
<td>Semiconductor Devices and Integrated Circuit Technology</td>
</tr>
<tr>
<td>NE 215</td>
<td>3:0</td>
<td>Aug</td>
<td>Applied Solid State Physics</td>
</tr>
<tr>
<td>NE 222</td>
<td>3:0</td>
<td>Aug</td>
<td>MEMS: Modeling, Design, and Implementation</td>
</tr>
<tr>
<td>NE 241</td>
<td>3:0</td>
<td>Aug</td>
<td>Material Synthesis: Quantum Dots to Bulk Crystals</td>
</tr>
<tr>
<td>NE 202</td>
<td>0:1</td>
<td>Jan</td>
<td>Device Fabrication Lab Module (Micro and Nano Fabrication)</td>
</tr>
<tr>
<td>Course Code</td>
<td>Credits</td>
<td>Semester</td>
<td>Description</td>
</tr>
<tr>
<td>-------------</td>
<td>---------</td>
<td>----------</td>
<td>-------------</td>
</tr>
<tr>
<td>NE 201</td>
<td>2:1</td>
<td>Jan</td>
<td>Micro and Nano Characterization Methods</td>
</tr>
<tr>
<td>NE 314</td>
<td>3:0</td>
<td>Jan</td>
<td>Semiconductor Opto-electronics and Photovoltaics</td>
</tr>
<tr>
<td>NE 221</td>
<td>2:1</td>
<td>Jan</td>
<td>Advanced MEMS Packaging Lab: Packaging Lab</td>
</tr>
<tr>
<td>IN 221</td>
<td>3:0</td>
<td>Aug</td>
<td>Sensors and Transducers</td>
</tr>
<tr>
<td>IN 229</td>
<td>3:0</td>
<td>Aug</td>
<td>Advanced Instrumentation Electronics</td>
</tr>
<tr>
<td>IN 212</td>
<td>3:0</td>
<td>Jan</td>
<td>Advanced Nano/Micro Systems</td>
</tr>
<tr>
<td>IN 214</td>
<td>3:0</td>
<td>Jan</td>
<td>Semiconductor Devices and Circuits</td>
</tr>
<tr>
<td>IN 224</td>
<td>3:0</td>
<td>Jan</td>
<td>Nanoscience and Device Fabrication</td>
</tr>
<tr>
<td>MT 209</td>
<td>3:0</td>
<td>Aug</td>
<td>Defects in Materials</td>
</tr>
<tr>
<td>MT 213</td>
<td>3:0</td>
<td>Jan</td>
<td>Electronic Properties of Materials</td>
</tr>
<tr>
<td>E3 257</td>
<td>2:1</td>
<td>Jan</td>
<td>Embedded System Design</td>
</tr>
<tr>
<td>E3 276</td>
<td>2:1</td>
<td>Jan</td>
<td>Process Tech &amp; System Eng for Adv Microsensors and Devices</td>
</tr>
<tr>
<td>PH 203</td>
<td>3:0</td>
<td>Aug</td>
<td>Quantum Mechanics-I</td>
</tr>
<tr>
<td>PH 208</td>
<td>3:0</td>
<td>Jan</td>
<td>Condensed Matter Physics-I</td>
</tr>
<tr>
<td>PH 352</td>
<td>3:0</td>
<td>Jan</td>
<td>Semiconductor Physics</td>
</tr>
<tr>
<td>PH 359</td>
<td>3:0</td>
<td>Jan</td>
<td>Physics at Nanoscale</td>
</tr>
<tr>
<td>MR 303</td>
<td>3:0</td>
<td>Aug</td>
<td>Nanomaterials Synthesis and Devices</td>
</tr>
<tr>
<td>MR 307</td>
<td>3:0</td>
<td>Jan</td>
<td>Thin Film, Nano Materials and Devices: Science and Engineering</td>
</tr>
<tr>
<td>MR 308</td>
<td>2:1</td>
<td>Jan</td>
<td>Computational Modeling of Materials</td>
</tr>
</tbody>
</table>

**Project: 28 Credits**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>MV 299</td>
<td>00:28</td>
</tr>
</tbody>
</table>
Electrical Communication Engineering

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

E2 201 (AUG) 3:0
Information Theory

Measures of information and their properties: entropy, mutual information, Kullback-Leibler divergence, total variation distance; information theoretic lower bounds, data compression, channel codes and channel capacity

Himanshu Tyagi

References :
- T. M. Cover and J. A. Thomas, Elements of Information Theory, 2nd edition, John Wiley & Sons
- T. S. Han, Information spectrum methods in Information Theory, Stochastic Modeling and Applied Probability series, Springer

Pre-requisites :
- Undergraduate level probability

E2 202 (AUG) 3:0
Random Processes


Parimal Parag

References :
- B. Hajek, An Exploration of Random Processes for Engineers, Course Notes, 2009,
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, cyclic codes; polar codes and Reed-Muller codes.

Navin Kashyap, Vijay Kumar P

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

E2 206 (AUG) 3:0
Quantum Information Theory
Syllabus: Review of Linear algebra, Quantum axioms, Quantum gates, basic Quantum algorithms, Quantum entanglement, Quantum error correction codes. Quantum channels, State and channel distance measures, Quantum entropy, source coding. Quantum channel capacity: classical capacity of quantum channels, entanglement-assisted classical capacity. Quantum information over quantum channel. Quantum capacity.

Vinod Sharma

References:
• M M Wilde, From Classical to Quantum Information Theory, 2nd ed, CUP, 2016.
• M A Nielsen and I L Chuang, Quantum Computation and Quantum Information CUP, 2000.

Pre-requisites:
• A basic course in probability, matrices and linear algebra.

E2 207 (AUG) 3:0
Concentration Inequalities
Limit results and concentration bounds: Chernoff bounds; Hoeffding’s inequality, Bennett’s inequality, Bernstein’s inequality; variance bounds: Efron-Stein inequality, Poincare inequality; the entropy method and bounded difference inequalities; log-Sobolev inequalities and hypercontractivity; Talagrand’s convex distance inequality; the transportation method; influences and threshold phenomena

Aditya Gopalan, Himanshu Tyagi

References:

Pre-requisites:
• A course on either probability, random processes or measure theory. Basic mathematical maturity and working familiarity with probability calculations.

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

Chandra R Murthy

References :
• Carl D Meyer, Matrix Analysis and Applied Linear Algebra, SIAM Publication, 2000

Pre-requisites :
• Undergraduate linear algebra

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.

Rahul Singh

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, I/Q imbalance, DC offset correction, error vector magnitude (EVM), power amplifier (PA) non-linearities; impact of PA distortions in OFDM, PAPR issues, CFO estimation and correction, SFO estimation and correction. Visible light wireless communications (VLC); transmitter, channel, receiver, performance, MIMO-VLC. Deep neural networks (DNNs) in communication systems design.

Chockalingam A

References :
• Research papers
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.

E3 220 (AUG) 3:0
Foundations of Nanoelectronic Devices

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

Kausik Majumdar

References:
• D. J. Griffiths, Introduction of Quantum Mechanics, Prentice Hall.
• A. Ghatak and S. Lokanathan, Quantum Mechanics, Trinity Press.
• V. K. Thakkarpan, Quantum Mechanics, New Age.
• A. Ghatak and S. Lokanathan, Quantum Mechanics, Trinity Press
• V. K. Thakkarpan, Quantum Mechanics, New Age
• N. W. Ashcroft and N. D. Mermin, Solid State Physics, Cengage Learning
• S. M. Sze, Physics of Semiconductor devices, Wiley-Interscience

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

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; Magnetostatic formulation; Electric Field Integral Equation; Magnetic Field Integral Equation; Direct and Iterative Solvers; Finite difference time domain methods: 1D wave propagation, yee Algorithm; Numerical dispersion and stability. Perfectly matched absorbing boundary conditions. Dispersive materials. Antenna and scattering problems with FDTD. non-uniform grids, conformal grids, periodic structures, RF circuit, Advanced topics in numerical electrodynamics based on recent literature. About the course: The course will have programming assignments (using Matlab/fortran/C++).
DipanjanGope, Vinoy K J

References:

E9 208 (AUG) 3:1
Digital Video: Perception and Algorithms

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

Rajiv Soundararajan

References:
- A. C. Bovik, Al Bovik’s Lecture Notes on Digital Video, The University of Texas at Austin, 2020

E9 211 (AUG) 3:0
Adaptive Signal Processing


Sundeep Prabhakar Chepuri

References:

MV 299 (AUG) 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 a specified period and should submit the Project Report for final evaluation.

Navin Kashyap

CN 299 (JAN) 0:28
Project (M.Tech., Communication and Networks)

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
E1 244 (JAN) 3:0
Detection and Estimation Theory

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

E2 203 (JAN) 3:0
Wireless Communication
Wireless channel modeling; diversity techniques to combat fading; cellular communication systems, multiple-access and interference management; capacity of wireless channels; opportunistic communication and multiuser diversity; MIMO – channel modeling, capacity and transmit and receiver architectures; OFDM.

Neelesh B Mehta
References :

E2 208 (JAN) 3:0
Topics in Information Theory and Coding
Low-Latency Codes: Streaming Codes, Fountain and Raptor codes, Gilbert-Elliott Channel, ARQ Methods, relevance to 5G..

Vijay Kumar P
References :
• From journal articles.
Pre-requisites :
• Background in Coding theory. (E2 205).

E2 209 (JAN) 3:0
Topics in Information Theory & Statistical Learning
This course will cover the basics of, and some recent advances in, the use of information theoretic techniques in statistical learning. The following topics will be covered: Hypothesis testing and minimax estimation; maximum likelihood estimation; asymptotic optimality; local asymptotic normality; sample optimal testing and estimation (uniformity testing, equality testing, independence testing, missing mass estimation, support estimation, learning Gaussian mixtures); information criteria for model selection (AIC, BIC, MDL); topics in nonparametric estimation.

Himanshu Tyagi
Pre-requisites :
**E2 236 (JAN) 3:1**

**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

**E2 241 (JAN) 3:0**

**Wireless 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:
- Selected journal papers

Pre-requisites:
- E2 205 (Error-Correcting Codes)

E2 334 (JAN) 3:0
Topics in Computation over Networks

Parimal Parag

References:
- Information, Physics, and Computation, Mezard, Montanari
- Random graphs and complex networks, Remco van der Hofstad

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

Varun Raghunathan, Srinivas T

References:
• E. J. Murphy, (Editor), Integrated Optical Circuits and Components: Design and Applications, Marcel and Dekker, 1999.
• 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 disciplines 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 (responsivity, gain and speed), and noise processes in detection. Light modulation: Electro-optic devices, amplitude and phase modulation, Franz-Keldysch 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:

E7 221 (JAN) 2:1
Fiber-Optic Communication

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

Shivaleela E S, Srinivas T

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

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

Dipanjan Gope

References :

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

This course will cover concepts related to the use of multiple sensors to solve problems related to the Direction of Arrival Estimation using Sensor arrays, 5G Wireless Communication Systems, and other applications.

Hari K V S

References :
• Array Signal Processing: Concepts and Techniques by Dan E. Dudgeon and Don H. Johnson
• Detection, Estimation, and Modulation Theory, Optimum Array Processing by Harry L. Van Trees
E9 271 (JAN) 3:0

Space-Time Signal Processing and Coding

Cache-aided communication; Wireline and wireless network coding; Device-to-Device (D2D) communications; Vehicular (V2V, V2X, I2V) communications; Multi-user and Multiple-Input Multiple-Output (MIMO) communication systems; Coding and algorithms for broadcast, multicast and interference channels; Distributed Space-Time Code construction and signal processing algorithms.

Sundar Rajan B

References:
• Current literature

Pre-requisites:
• Basic course in Digital Communication

MV 299 (JAN) 0:28

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

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

CN 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
COURSE STRUCTURE: 64 Credits (40 Credits course work + 24 Credits project)

**Hard Core (ALL courses compulsory)**

<table>
<thead>
<tr>
<th></th>
<th>Course Code</th>
<th>Credits</th>
<th>Course Name</th>
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<tbody>
<tr>
<td>1</td>
<td>E4 234</td>
<td>3:0</td>
<td>Advanced Power System Analysis</td>
</tr>
<tr>
<td>2</td>
<td>E5 201</td>
<td>2:1</td>
<td>Production, Measurement and Application of High Voltage</td>
</tr>
<tr>
<td>3</td>
<td>E6 201</td>
<td>3:1</td>
<td>Power Electronics</td>
</tr>
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**Soft Core (Pick any FIVE out of NINE)**

<table>
<thead>
<tr>
<th></th>
<th>Course Code</th>
<th>Credits</th>
<th>Course Name</th>
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<tbody>
<tr>
<td>1</td>
<td>E1 241</td>
<td>3:0</td>
<td>Dynamics of Linear Systems</td>
</tr>
<tr>
<td>2</td>
<td>E8201</td>
<td>3:0</td>
<td>Electromagnetism</td>
</tr>
<tr>
<td>3</td>
<td>E4 231</td>
<td>3:0</td>
<td>Power System Dynamics &amp; Control</td>
</tr>
<tr>
<td>4</td>
<td>IN 227</td>
<td>3:0</td>
<td>Control System Design</td>
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<tr>
<td>5</td>
<td>E3 252</td>
<td>3:1</td>
<td>Embedded System Design for Power Application</td>
</tr>
<tr>
<td>6</td>
<td>E4 233</td>
<td>3:0</td>
<td>Computer Control of Power Systems</td>
</tr>
<tr>
<td>7</td>
<td>E5 206</td>
<td>3:0</td>
<td>HV Power Apparatus</td>
</tr>
<tr>
<td>8</td>
<td>E5 209</td>
<td>3:0</td>
<td>Overvoltages in Power Systems</td>
</tr>
<tr>
<td>9</td>
<td>E6 211</td>
<td>3:0</td>
<td>Electric Drives</td>
</tr>
</tbody>
</table>

Project: 24 Credits

**EP 299(EE) 0:24  Dissertation Project**

Electives: The balance of credits to make up the minimum of 64 credits required to complete the MTech Degree Programme (all at 200 level or higher)

**NOTE:** This structure is applicable to students admitted in 2020.
MTech Degree in Signal Processing - 2020
(Duration 2 years)

COURSE STRUCTURE: 64 Credits (36 Credits course work + 28 Credits project)

<table>
<thead>
<tr>
<th>Course Structure</th>
<th>Credits</th>
<th>Course Name</th>
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<tbody>
<tr>
<td><strong>Hard Core (12 Credits) (All courses compulsory)</strong></td>
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</tr>
<tr>
<td>Jan</td>
<td>E1 244</td>
<td>Detection and Estimation Theory</td>
</tr>
<tr>
<td>Aug</td>
<td>E1 251</td>
<td>Linear and Nonlinear Optimization</td>
</tr>
<tr>
<td>Aug</td>
<td>E2 202</td>
<td>Random Processes</td>
</tr>
<tr>
<td>Aug</td>
<td>E2 212</td>
<td>Matrix Theory</td>
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<table>
<thead>
<tr>
<th>Course Structure</th>
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<tbody>
<tr>
<td><strong>Soft Core (Minimum of 12 Credits)</strong></td>
<td></td>
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</tr>
<tr>
<td>Jan</td>
<td>E1 213</td>
<td>Pattern Recognition and Neural Networks</td>
</tr>
<tr>
<td>Jan</td>
<td>E1 216</td>
<td>Computer Vision</td>
</tr>
<tr>
<td>Aug</td>
<td>E2 211</td>
<td>Digital Communication</td>
</tr>
<tr>
<td>Aug</td>
<td>E9 211</td>
<td>Adaptive Signal Processing</td>
</tr>
<tr>
<td>Jan</td>
<td>E9 213</td>
<td>Time-Frequency Analysis</td>
</tr>
<tr>
<td>Aug</td>
<td>E9 221</td>
<td>Signal Quantization and Compression</td>
</tr>
<tr>
<td>Jan</td>
<td>E9 231</td>
<td>MIMO Signal Processing</td>
</tr>
<tr>
<td>Aug</td>
<td>E9 241</td>
<td>Digital Image Processing</td>
</tr>
<tr>
<td>Aug</td>
<td>E9 261</td>
<td>Speech Information Processing</td>
</tr>
<tr>
<td>Aug</td>
<td>E9 291</td>
<td>DSP System Design</td>
</tr>
</tbody>
</table>

**Project: 28 Credits**
EP 299(SP) 0:28 Dissertation Project - The project code needs to changed suitably

Electives: The balance of 12 credits to make up the minimum of 64 credits required to complete the MTech degree (all at 200 level or higher) must be obtained through electives from within/outside the EE and ECE departments, taken with the approval of the Faculty advisor/DCC.
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. Laboratory will be by using simulator

Rathna G N

References:
- WIRELESS SENSOR NETWORKS Technology, Protocols, and Applications by KAZEM SOHRABY DANIEL MINOLI TAIEB ZNATI

Pre-requisites:
- Consent of Instructor

E0 299 (AUG) 3:1

Computational Linear Algebra

Theory: Solution of linear equations, vector space, linear transformations, matrix representation, inner-products and norms, orthogonality and least-squares, trace and determinant, eigendecomposition, symmetric (Hermitian) matrices and quadratic forms, singular value decomposition. Computations: linear solvers, least squares, QR (Gram-Schmidt), SVD.

Kunal Narayan Chaudhury

References:

Pre-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

Asymptotic observers, compensator design, and separation principle. Preliminary quadratic regulator theory.

Vaibhav Katewa, Pavankumar Tallapragada

References:

E1 246 (AUG) 3:0
Topics in Networked and Distributed Control
Core topics: Relevant background topics in control, Estimation and control under communication constraints such as sampling, quantization, packet losses, time delays; data rate limited control; Consensus, synchronization, coverage control, multi-agent systems. Selected topics from: Event-triggered control, connectivity maintenance, distributed estimation, distributed optimization, distributed hypothesis testing, privacy and security in networked and distributed control systems, social networks, opinion dynamics, epidemic spread, applications in robotics and transportation

Vaibhav Katewa, Pavankumar Tallapragada

References:
• 6. Current literature

Pre-requisites:
• Some background in graduate level control and/or related areas such as linear systems theory, nonlinear systems, random processes. Permission of the instructor.

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 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**


**References**:

**E5 206 (AUG) 3:0**

**HV Power Apparatus**

HV power transformers, equivalent circuit, surge phenomenon, standing and traveling wave theory, ladder network representation, short circuit forces, impulse testing, diagnostics and 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**:

**E6 211 (AUG) 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 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 226 (AUG) 3:0
Switched Reluctance Machines and Drives
Review of magnetic circuits, energy stored in a magnetic circuit, magnetic circuits with a moving / rotating element in the air gap, force / torque as a partial derivative of stored energy with respect to linear / angular position of the moving / rotating element, effect of magnetic saturation. Constructional features of switched reluctance machines, doubly salient structure, examples of 6/4 and 8/6 machines, basic operating principle, study of motor behaviour from stator terminals, current response to fixed stator voltage with rotor blocked, static flux-linkage characteristics, static torque characteristics, inductance profile at low currents, total and incremental inductances, motoring and generating based on inductance profile, motoring and generating based on flux-linkage characteristics, back-emf response to constant current injection at constant rotor speed, back-emf characteristics. DC-DC converters, asymmetric and symmetric H-bridge converters; current control of DC-DC converters with passive and active loads; current control of DC-AC converters with passive loads, loads with sinusoidal back emf, and loads with non-sinusoidal back emf. Current control of switched reluctance machine, square wave current reference for motoring and generating, current tracking, hysteresis control or delta modulation, PWM control, PI based current control, linearization of nonlinear plant for controller design, equilibrium points for linearization, frequency responses of linearized models, selection of controller parameters, back-emf estimation, back-emf compensation. Phase current, phase torque and total torque; average torque, torque pulsations, current reference waveshapes to reduce torque pulsation; structure for torque control and speed control; torque reference and torque controller design; speed controller design. Reference: T.J.E Miller, “Switched reluctance motors and their control”, Magna Physics Publishing, Oxford Science Publications, 1993 T.J.E. Miller, “Electronic control of switched reluctance machines,” Newnes Power Engineering Series, 2001 K. Venkataratnam, “Special electric machines,” Orient Black Swan, 2008 Krishnan Ramu, “Switched reluctance motor drives: modeling, simulation, analysis, design and application,” CRC Press, 2001 Recent research publications

Narayanan G

E8 201 (AUG) 3:0
Electromagnetism
Review of basic electrostatics, dielectrics and boundary conditions, systems of charges and conductors, Green’s reciprocity theorem, eldstance and capacitance co-eficient, 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:

E9 241 (AUG) 2:1

Digital Image Processing

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

Soma Biswas, Rajiv Soundararajan

References:
- A. C. Bovik, Ali Bovik’s Lecture Notes on Digital Image Processing, The University of Texas at Austin, 2019

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:
- Current literature

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 MATLAB and CCS 5.4 simulator

Rathna G N

References:

Scheme of Instruction 2020 - 2021
E9 309 (AUG) 3:1

Advanced Deep Learning


Sriram Ganapathy

References:
- Research papers/tutorials in the domain, Lecture notes in pdf format.
- Deep Learning, Ian Goodfellow and Yoshua Bengio and Aaron Courville, MIT Press 2016

Prerequisites:
- Basic machine learning/pattern recognition course. Good background in python programming

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, 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 213 (JAN) 3:1

Pattern Recognition and Neural Networks

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

Subbayya Sastry P

Pre-requisites:

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:
• Brown s, and Vranesic Z, Fundamentals of Digital logic with Verilog design, Tata McGraw Hill. Mazidi, McKinlay and Causey, PIC Micro

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 221 (JAN) 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.

Jayachandra Shenoy U

References :

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

GurunathGurrala

E4 238 (JAN) 3:0
Advanced Power System Protection

Overview of over-current, directional, distance and differential, out-of-step; protection and fault studies; Service conditions and ratings of relays; Impact of CVT transients on protection; Current Transformer: accuracy classes, dynamic characteristics, impact and detection of saturation, choice for an application; Circuit Breaker: need for breaker failure protection, breaker failure protection schemes, design considerations for breaker failure protection; Transmission line protection: issues and influencing factors, definitions of short, medium and long lines using S/I, 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 schemes 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 :
E5 201 (JAN) 2:1
Production, Measurement, and Application of High Voltage

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

Subba Reddy Basappa, Rajanikanth B  S

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

E5 209 (JAN) 3:0
Over voltages in Power Systems

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

E5 232 (JAN) 2:1
Advances in Electric Power Transmission

- Recent advances in UHV power transmission - introduction to 765/1200kV AC and ±500/800 kV DC transmission systems; present status and future growth. • Design criteria for overhead transmission lines: general system design, methodology, reliability, wind/ice loading, security and safety requirements.
Components of HV transmission systems, types of conductors/HTLS, bundle configurations, conductor accessories/clamps etc. • Transmission towers: calculations of clearances for power frequency, switching and lightning surges, right of way (ROW), earth wire/OPGW, • Selection of insulators for light, medium and heavy polluted areas. • Up-gradation of existing transmission lines, • Design considerations of UHV Substations, Comparison of AIS, Hybrid-AIS and GIS. • Review on insulation coordination/overvoltages for UHV systems-high performance metal oxide surge arresters, Introduction to SCADA and Substation automation. • Earthing and safety measures for 765/1200kV HV substations. • Field / Industry visit – Substation / Industry • Assignment - involving computation of potential distribution, ground end electric & magnetic fields.

Subba Reddy Basappa
References :
• 6. Recent IEEE, CIGRE, IEC Standards and other International publications

E6 201 (JAN) 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 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:

E6 225 (JAN) 3:0

Advanced Power Electronics


Kaushik Basu

References:

Pre-requisites:
- E6 201:Power Electronics or E6 202: Design of Power Converters

E9 205 (JAN) 3:1

Machine Learning for Signal Processing


Sriram Ganapathy

References:

Pre-requisites:
- Random Process / Probability and Statistics
- Linear Algebra / Matrix Theory

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


Soma Biswas, Rajiv Soundararajan

References:

Pre-requisites:
- E9 241: Digital Image Processing

E9 261 (JAN) 3:1
Speech Information Processing

Human speech communication: physiology of speech production, phonetics and phonology, speech perception and illusions, time-domain features; Time-varying system and signal analysis: short-time Fourier transform; Spectrogram and Applications - pitch and time scale modification; Quasi-stationary analysis: cepstrum, Mel frequency cepstral coefficients; AM-FM, sinusoidal models for speech; Linear Prediction, AR and ARMA modeling of speech; Sequence Modeling of Speech - Dynamic Time Warping, Introduction to Hidden Markov Models; Deep learning for Sequence Modeling - Recurrent neural networks, attention based models. Speech applications - Automatic speech recognition. Course assignments and mini-project include programming and voice recordings.

Prasanta Kumar Ghosh

References:

Pre-requisites:
- E9-201 or consent of the instructor.
E9 282 (JAN) 2:1

**Neural Signal Processing**

Techniques for the analysis of action potentials, Local Field Potential (LFP) and Electroencephalogram (EEG). Techniques include stochastic processes, time-frequency analysis, sparse signal processing, coherence, ICA/PCA, forward and inverse modeling, Granger causality, and linear discriminant analysis.

**Chandra Sekhar Seelamantula, Supratim Ray**

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 :**

- (2) Sebastian Seung. Connectome: How the brain’s wiring makes us who we are. HMH, 2013.
- (7) Recent Literature.

**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

EE 299 (JAN) 0:24

**Project**

MTech EE Project

Satish L

SP 299 (JAN) 0:28

**Project**

MTech SP Project

Navin Kashyap, Satish L
# Dept of Electronic Systems Engineering

## M Tech Electronic Systems Engineering

<table>
<thead>
<tr>
<th>Duration: 2 Years</th>
<th>Total Credits: 64</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Core Courses:</strong> 15 credits (All courses are compulsory)</td>
<td></td>
</tr>
<tr>
<td>E0 284</td>
<td>2:1</td>
</tr>
<tr>
<td>E2 243</td>
<td>2:1</td>
</tr>
<tr>
<td>E3 204</td>
<td>3:0</td>
</tr>
<tr>
<td>E3 235</td>
<td>2:1</td>
</tr>
<tr>
<td>E3 257</td>
<td>2:1</td>
</tr>
</tbody>
</table>

**Electives:** 24 Credits (all at 200 level or higher) from the following courses or any other courses listed in the Scheme of Instructions.

| E1 201 | 2:1 | Jan | Hardware Acceleration and Optimization for Machine Learning |
| E1 243 | 2:1 | Jan | Digital Controller Design |
| E2 230 | 3:0 | Aug | Network Science and Modeling |
| E2 231 | 3:0 | Jan | Topics in Statistical Methods |
| E2 232 | 2:1 | Aug | TCP-IP Networking |
| E3 200 | 1:2 | Jan | Microelectronics Lab |
| E3 225 | 3:0 | Jan | Art of Compact Modeling |
| E3 231 | 2:1 | Jan | Digital System Design with FPGAs |
| E3 245 | 2:1 | Aug | Processor System Design |
| E3 258 | 2:1 | Jan | Design for Internet of Things |
| E3 260 | 2:1 | Aug | Embedded System Design II |
| E3 271 | 1:2 | Jan | Reliability of Nanoscale Circuits and Systems |
| E3 272 | 3:0 | Jan | Advanced ESD Devices, Circuits and Design Methods |
| E3 274 | 1:2 | Jan | Design of Power Semiconductor Devices |
| E3 275 | 2:1 | Jan | Physics and Design of Transistors |
| E3 276 | 2:1 | Jan | Process Technology and System Engineering for Advanced Microsensors and Devices |
| E3 282 | 3:0 | Jan | Basics of Semiconductor Devices and Technology |
| E3 301 | 3:0 | Jan | Special Topics in Nanoelectronics |
| E6 202 | 2:1 | Jan | Design of Power Converters |
| E6 212 | 3:0 | Jan | Design and Control of Power Converters and Drives |
| E6 222 | 2:1 | Jan | Design of Photovoltaic Systems |
| E9 251 | 3:0 | Jan | Signal Processing for Data Recording Channels |
| E9 252 | 3:0 | Jan | Mathematical Methods and Techniques in Signal Processing |
| E9 253 | 3:1 | Aug | Neural Networks and Learning Systems |

**Project:** 25 Credits

| ED 299 | 0:25 | Dissertation Project |

Scheme of Instruction 2020 - 2021
Departments of Electronic Systems Engineering and Electrical Communication Engineering
MTech Microelectronics and VLSI Design

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Credits</th>
<th>Semester</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>E0 284</td>
<td>2:1</td>
<td>Aug</td>
<td>Digital VLSI Circuit</td>
</tr>
<tr>
<td>E3 200</td>
<td>1:2</td>
<td>Jan</td>
<td>Microelectronics Lab</td>
</tr>
<tr>
<td>E3 220</td>
<td>3:0</td>
<td>Aug</td>
<td>Foundations of Nanoelectronics Devices</td>
</tr>
<tr>
<td>E3 231</td>
<td>2:1</td>
<td>Jan</td>
<td>Digital Systems Design with FPGAs</td>
</tr>
<tr>
<td>E3 238</td>
<td>2:1</td>
<td>Aug</td>
<td>Analog VLSI Circuits</td>
</tr>
<tr>
<td>E3 282</td>
<td>3:0</td>
<td>Jan</td>
<td>Basics of Semiconductor Devices and Technology</td>
</tr>
</tbody>
</table>

Core Courses: 18 credits, mandatory for all students.
Total Credits: 64

Electives: 18 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>Credits</th>
<th>Semester</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1 201</td>
<td>2:1</td>
<td>Jan</td>
<td>Hardware Acceleration and Optimization for Machine Learning</td>
</tr>
<tr>
<td>E3 225</td>
<td>3:0</td>
<td>Aug</td>
<td>Art of Compact Modelling</td>
</tr>
<tr>
<td>E3 237</td>
<td>3:0</td>
<td>Jan</td>
<td>Integrated Circuits for Wireless Communication</td>
</tr>
<tr>
<td>E3 245</td>
<td>2:1</td>
<td>Aug</td>
<td>Processor System Design</td>
</tr>
<tr>
<td>E3 257</td>
<td>2:1</td>
<td>Jan</td>
<td>Embedded System Design</td>
</tr>
<tr>
<td>E3 271</td>
<td>1:2</td>
<td>Jan</td>
<td>Reliability of Nanoscale Circuits and Systems</td>
</tr>
<tr>
<td>E3 274</td>
<td>1:2</td>
<td>Jan</td>
<td>Design of Power Semiconductor Devices</td>
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<tr>
<td>E3 275</td>
<td>2:1</td>
<td>Jan</td>
<td>Physics and Design of Transistors</td>
</tr>
<tr>
<td>E3 276</td>
<td>2:1</td>
<td>Jan</td>
<td>Process Tech &amp; System Eng for Adv Microsensors and Devices</td>
</tr>
<tr>
<td>E3 280</td>
<td>3:0</td>
<td>Jan</td>
<td>Carrier Transport in Nanoelectronics Devices</td>
</tr>
<tr>
<td>E3 301</td>
<td>3:0</td>
<td>Jan</td>
<td>Special topics in Nanoelectronics</td>
</tr>
<tr>
<td>E7 211</td>
<td>2:1</td>
<td>Jan</td>
<td>Photonic Integrated Circuits</td>
</tr>
<tr>
<td>E7 214</td>
<td>3:0</td>
<td>Jan</td>
<td>Optoelectronic Devices</td>
</tr>
<tr>
<td>E8 202</td>
<td>2:1</td>
<td>Aug</td>
<td>Computational Electromagnetics</td>
</tr>
<tr>
<td>E8 242</td>
<td>2:1</td>
<td>Jan</td>
<td>RF IC and Systems</td>
</tr>
<tr>
<td>E8 262</td>
<td>3:0</td>
<td>Jan</td>
<td>CAD for High Speed Chip-Package-Systems</td>
</tr>
<tr>
<td>NE 203</td>
<td>3:0</td>
<td>Aug</td>
<td>Advanced Micro and Nano Fabrication Tech and Process</td>
</tr>
<tr>
<td>NE 205</td>
<td>3:0</td>
<td>Aug</td>
<td>Semiconductor Devices and Integrated Circuit Technology</td>
</tr>
<tr>
<td>NE 215</td>
<td>3:0</td>
<td>Aug</td>
<td>Applied Solid State Physics</td>
</tr>
<tr>
<td>NE 222</td>
<td>3:0</td>
<td>Aug</td>
<td>MEMS: Modeling, Design, and Implementation</td>
</tr>
<tr>
<td>NE 241</td>
<td>3:0</td>
<td>Aug</td>
<td>Material Synthesis: Quantum Dots to Bulk Crystals</td>
</tr>
<tr>
<td>NE 202</td>
<td>0:1</td>
<td>Jan</td>
<td>Device Fabrication Lab Module (Micro and Nano Fabrication)</td>
</tr>
<tr>
<td>NE 201</td>
<td>2:1</td>
<td>Jan</td>
<td>Micro and Nano Characterization Methods</td>
</tr>
<tr>
<td>NE 314</td>
<td>3:0</td>
<td>Jan</td>
<td>Semiconductor Opto-electronics and Photovoltaics</td>
</tr>
<tr>
<td>NE 221</td>
<td>2:1</td>
<td>Jan</td>
<td>Advanced MEMS Packaging Lab: Packaging Lab</td>
</tr>
<tr>
<td>IN 221</td>
<td>3:0</td>
<td>Aug</td>
<td>Sensors and Transducers</td>
</tr>
</tbody>
</table>
### E0 284 (AUG) 2:1
**Digital VLSI Circuits**
Introduction to MOS transistor theory, circuit characterization and simulation, theory of logical effort and delay, combinational and sequential circuit design, standard cell layout, datapath subsystems, power and clock distribution, ASIC Chip Design methodology & tools including synthesis, design for test (DFT), place & route, verification.

**Chetan Singh Thakur**

**References :**
- N. Weste and D. Harris, CMOS VLSI Design. A Circuits and Systems Perspective, Addison Wesley, 2005
- Current literature

### E2 232 (AUG) 2:1
**TCP/IP Networking**
IP addressing, IP header; subnetting and supernetting, CIDR, routing table, Ethernet, Frame Processing in Linux kernel, ARP; 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; Private IP; NAT; DHCP; http; Web application security; SDN; 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 235 (AUG) 2:1

Design for Analog Circuits

Introduction to Op-Amps and Op-Amp Circuits, Single-Stage and Two-Stage Amplifiers, Amplifier types and Topologies, Instrumentation Amplifiers; Static and dynamic Errors in Op-Amp; Practical Application of transistors and Op-Amps, Error budgeting in various circuits; Current Mirrors, CCS and Active Loads, Temperature indicators and controllers, PID-controllers: Voltage regulators and power supplies, protection circuits; 4-20mA and other current transmitters; Designing Analog Circuits: Active Filters, LPF, HPF, BPF, BRF; Frequency Response and Feedback techniques; Nonlinear circuits, nonlinear and exponential transfer characteristics, Triggers, Comparators, rectifiers; Waveform generators, positive feedback, Oscillators, Converters; Instability and compensation; ADCs and DACs; Circuit simulation using Kicad and Ngspice; Understanding Datasheets.

Nagakrishna V

References :
• Sergio Franco, Design- With-Operational-Amplifiers-And-Analog-Integrated
• Peter D. Hiscocks, Analog Circuit Design

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
• Computer Architecture: A Quantitative Approach, The Morgan Kaufmann By John L. Hennessy and David A. Patterson
• Current Literature

Pre-requisites :
• E3 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.

Umanand L
References :
• Rao R Tummala & Madhavan Swaminathan, Introduction to System-on-Package, McGraw Hill, 2008,
• R S Khandpur, Printed Circuit Boards, McGraw Hill, 2006

E9 253 (AUG) 3:1
Neural Networks and Learning Systems
Introduction, models of a neuron, neural networks as directed graphs, network architectures (feedforward, 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, 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, representer 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

AI 299 (JAN) 0:21
MTech AI Dissertation Project
MTech AI Dissertation Project

Kuruvilla Varghese

E1 201 (JAN) 2:1

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

Chetan Singh Thakur

References:
- Current literature

Pre-requisites:
- Basics of linear algebra, calculus, probability, basic knowledge of C/Python

E1 243 (JAN) 2:1

Digital Controller Design
Modelling of physical systems using bondgraph, state space representation, transfer function, z-domain analysis, continuous to discrete transformations, controller design using discrete root locus, controller design using full state feedback, output feedback, observer, reduced order observer, observer design, optimal controller and observer

Umanand L

References:
- Franklin, Workman and Powell, Digital control, Prentice Hall

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:
• M. Jordan (ed.), Learning in Graphical Models, MIT Press, 1998
• M. Mézard and A. Montanari, Information, Physics and Computation, Oxford University Press, 2009

E3 200 (JAN) 1:2
Microelectronics Lab

Mayank Shrivastava

E3 204 (JAN) 3:0
Fundamentals of MOS Analog Integrated Circuits

Sanjiv Sambandan

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

E3 225 (JAN) 3:0

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

E3 257 (JAN) 2:1

Embedded System Design

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

Dagale Haresh Ramji

References :
• Definitive Guide to Cortex M3 Architecture,JosephYiu
• Practical Microcontroller Engineering with ARM Technology,YingBai,Linkers& Loaders
Design for Internet of Things

Embedded Systems: Rise of embedded systems and their transition to intelligent systems and to Internet of Things - RFID s, 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

References:
- Barry, P., and Crowley, P., Modern Embedded Computing

Reliability of Nanoscale Circuits and Systems

Carrier transport and carrier energy fundamentals, avalanche multiplication and breakdown, hot carrier induced (HCI) degradation mechanism, NBTI/PBTI, TDDDB, 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 parasites, 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

References:
- Review Papers on NBTI/PBTI, HCI Degradation, TDDDB, Electromigration, ESD in Silicon Integrated Circuits by Ajith Amerasekera and CharvakaDuvvury, Wiley publication, Basic ESD and I/O Design by Sanjay Dabral and Timothy J. Maloney, Wiley publication

Advanced ESD Devices, Circuits and Design Methods

History of key inventions in the field of ESD and latch-up protection, Review on various ESD testers and ESD test models, problems associated with ESD testers and progress on ESD tester development. High current injection, High field effects, Negative differential resistance and Current filaments, Drain extended MOS devices and associated weak ESD robustness. ESD behavior of FinFET devices, SiGe-FET’s and other quantum well devices, Impact of stress & strain on ESD behavior, ESD devices in advanced CMOS and BiCMOS technology, Impact of technology scaling on ESD behavior, Special analog and RF ESD protection devices and circuits. Impact of ESD stress on CNTs, Graphene and other 2D material based Nanoelectronic devices. ESD Device modeling for circuit simulations, State-of-the-art on CDM ESD protection, CDM tester models, modeling CDM behavior and CDM simulations, ESD verification flow and methodology, Towards full chip ESD simulation, Transient latch-up, System level ESD, System efficient ESD design (SEED), Case studies.

Mayank Shrivastava

References:
- ESD Protection Device and Design for Advanced CMOS Technologies by Oleg Semenov, Hossein Sarbshiae and Manoj Sachdev, Elsevier
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 design essentials, breakdown voltage and on-resistance trade-off, self heating effects and filament formation.

Mayank Shrivastava

References:

E3 275 (JAN) 2:1

Physics and Design of Transistors


Mayank Shrivastava

Pre-requisites:
- Lecture Notes, Physics of Semiconductor Devices : S.M. Sze

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

E3 282 (JAN) 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 heterojunctions 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

E3 301 (JAN) 3:0
Special Topics in Nanoelectronics
Physics of Constrained Dimensions: 0D Nano-devices (Quantum Dots), 1D Nano-devices (Nanowires, Nanotubes and Nano-Ribbons), 2D Nano-devices (TMDs, Phosphorene & Graphene); Two Dimensional Electron Gas and Quantum Well Systems, Electro-thermal, thermal and electrical transport in 0D, 1D and 2D systems (CNT, Graphene, h-BN, Phosphorene and TMDs); Noise in nano-structures and nano-devices; Nanoelectronic Memories and Memristors; Memristor-based Neuromorphic Systems; Emerging Nanophotonic Applications using 0D, 1D and 2D material systems; Applications of 2D material heterostructures in Photodetectors, memories, tunnel FETs and THz detectors; applications of Graphene-h-BN heterostructure and other applications of graphene.

Mayank Shrivastava
References:
• Review Articles
• Research Papers
Pre-requisites:
• E3-282: Basics of Semiconductor Devices and Technology
• E3-275: Physics and Design of Transistors

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
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 252 (JAN) 3:0
Mathematical methods and techniques in signal processing
Review of basic signals, systems and signal space: Review of 1-D signals and systems, review of random signals, multi-dimensional signals, review of vector spaces, inner product spaces, orthogonal projections and related concepts. Basics of multi-rate signal processing: sampling, decimation and interpolation, sampling rate conversion (integer and rational sampling rates), oversampled processing (A/D and D/A conversion), and introduction to filter banks. Signal representation: Transform theory and methods (FFT and variations, KLT), other transform methods. Statistical signal modeling: The least squares method, Pade's approximation, Prony's method, Shanks' method, iterative pre-filtering, all-pole modeling and linear prediction, autocorrelation and covariance methods, FIR least squares inverse filter design, applications and examples. Inverse problems (signal reconstruction): underdetermined least squares, pseudo-inverse (SVD), min-norm solutions, regularized methods, reconstruction from projections, iterative methods such as projection onto convex sets, expectationmaximization and simulated annealing.

ShayanGarani Srinivasas
Pre-requisites :

ED 299 (JAN) 0:25
MTech ESE Dissertation Project
MTech ESE Dissertation Project
Kuruvilla Varghese

MV 299 (JAN) 0:28
MTech Micro & VLSI Dissertation Project
MTech Microelectronics and VLSI Design Dissertation Project
Kuruvilla Varghese

References :
Division of Mechanical Sciences

Preface

The Division of Mechanical Sciences consists of the departments of Aerospace Engineering, Atmospheric and Oceanic Sciences, Civil Engineering, Chemical Engineering, Divecha Centre for Climate Change, Earth Sciences, Mechanical Engineering, Materials Engineering, Product Design and Manufacturing, and Sustainable Technology. It also 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.

<table>
<thead>
<tr>
<th>Code</th>
<th>Department</th>
</tr>
</thead>
<tbody>
<tr>
<td>AE</td>
<td>Aerospace Engineering</td>
</tr>
<tr>
<td>AS</td>
<td>Atmospheric and Oceanic Sciences</td>
</tr>
<tr>
<td>CE</td>
<td>Civil Engineering</td>
</tr>
<tr>
<td>CH</td>
<td>Chemical Engineering</td>
</tr>
<tr>
<td>DC</td>
<td>Divecha Centre of Climate Change</td>
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<tr>
<td>ER</td>
<td>Earth Sciences</td>
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<tr>
<td>ME</td>
<td>Mechanical Engineering</td>
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<td>MT</td>
<td>Materials Engineering</td>
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<tr>
<td>PD</td>
<td>Product Design and Manufacturing</td>
</tr>
<tr>
<td>ST</td>
<td>Sustainable Technologies</td>
</tr>
</tbody>
</table>

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. 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  
Dean  
Division of Mechanical Sciences
**Dept of Aerospace Engineering**

**MTech Curriculum**

Core courses → 15 credits
Experimental techniques in aerospace engineering → 1 credit
Aerospace seminar → 1 credit
Math requirement → 3 credits
MTech project dissertation → 20 credits
Electives → 24 credits

**Total → 64 credits (minimum)**

MTech Dissertation adviser to be chosen by the MTech student at the end of first semester.

Math requirement, all electives, and the independent study course, will be credited by a student in consultation with the MTech dissertation adviser. Students should register for a minimum of 12 credits per semester:

<table>
<thead>
<tr>
<th>Semester I</th>
<th>Semester 2</th>
<th>Semester 3</th>
<th>Semester 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flight and Space Mechanics</td>
<td>Math requirement</td>
<td>Aerospace Seminar</td>
<td></td>
</tr>
<tr>
<td><strong>Fluid Dynamics</strong></td>
<td>Elective 1</td>
<td>Elective 5</td>
<td></td>
</tr>
<tr>
<td>Mechanics and Thermodynamics of Propulsion</td>
<td>Elective 2</td>
<td>Elective 6</td>
<td></td>
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<tr>
<td>Flight Vehicle Structures</td>
<td>Elective 3</td>
<td>Elective 7</td>
<td></td>
</tr>
<tr>
<td>Navigation, Guidance and Control</td>
<td>Elective 4</td>
<td>Elective 8</td>
<td></td>
</tr>
<tr>
<td>Experimental Techniques in Aerospace Engineering</td>
<td></td>
<td></td>
<td>MTech Dissertation</td>
</tr>
<tr>
<td>16 credits</td>
<td></td>
<td></td>
<td>Distributed over 3rd and 4th semesters</td>
</tr>
</tbody>
</table>

**Core courses**

<table>
<thead>
<tr>
<th>Semester 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>48 credits</td>
</tr>
<tr>
<td>(Minimum 12 credits per semester)</td>
</tr>
</tbody>
</table>
AE 201 (AUG) 3:0  
**Flight and Space Mechanics**  

Ramesh O N  
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.  

Sourabh Suhas Diwan  
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 :  
• Nicholas Cumpsty and Andrew Heyes, Jet propulsion. Cambridge University Press, 2015.  

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.  

Dinesh Kumar Harursampath  
References :  

Scheme of Instruction 2020 - 2021
AE 205 (AUG) 3:0

Navigation, Guidance and Control

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

Ashwini Ratnou, Debasish Ghose, Suresh Sundaram

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

AE 227 (AUG) 3:0

Numerical Fluid Flow

Introduction to CFD, equations governing fluid flow, hyperbolic partial differential equations and shocks, finite difference technique and difference equations, implicit difference formula, time discretization and stability, schemes for linear convective equation, analysis of time integration schemes, monotonicity, schemes for Euler equations, finite volume methodology. Introduction to unstructured mesh computations.

Balakrishnan N(CFD)

References :

Pre-requisites :
• AE 202 or equivalent.

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 255 (AUG) 3:0
Aeroelasticity
Effect of wing flexibility on lift distribution; Torsional wing divergence; Vibration of single, two, and multi-degree of freedom models of wing with control surfaces; Unsteady aerodynamics of oscillating airfoil; Bending-torsion flutter of wing; Gust response of an aeroelastic airplane; Aeroservoelasticity of wing with control surfaces.

Kartik Venkatraman

References:

Prerequisites:
• A course in solid or fluid mechanics.

AE 261 (AUG) 3:0
Structural Vibration Control

SiddanagoudaKandagal

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

Prerequisites:
• 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.

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.

Arnab Samanta, Joseph Mathew

References:

**AE 221 (JAN) 3:0**

**Aerodynamics**

Introduction to aerodynamics, potential flows, conformal mapping and Joukowski 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.

Gopalan Jagadeesh, Joseph Mathew, Srisha Rao M V

References:

Pre-requisites:
• AE 202

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

**Numerical Fluid Flow**

Introduction to CFD, equations governing fluid flow, hyperbolic partial differential equations and shocks, finite difference technique and difference equations, implicit difference formula, time discretization and stability, schemes for linear convective equation, analysis of time integration schemes, monotonicity, schemes for Euler equations, finite volume methodology. Introduction to unstructured mesh computations.

Balakrishnan N(CFD)

References:

Pre-requisites:
• AE 202 or equivalent

**AE 229 (JAN) 3:0**

**Computational Gas Dynamics**

Scheme of Instruction 2020 - 2021

Raghurama Rao S V

References:
- Laney, B., Computational Gas Dynamics.

Pre-requisites:
- AE 202, AE 222, courses in Numerical Analysis/Numerical Methods, and any programming language.

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.

Dinesh Kumar Harursampath, Narayana Naik G

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 264 (JAN) 3:0

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

Kartik Venkatraman
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.

Ashwini Ratnoo, Debasish Ghose
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
Aerospace Seminar

Aerospace Seminar is a 1 credit course offered 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

Kartik Venkatraman

References :
• AE Seminar

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

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 :
• Sinha, A., Linear Systems: Optimal and Robust Control, CRC Press, 2007
• Lecture Notes.

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

M Tech Programme in Climate Science (2020 and LATER BATCH STUDENTS)

Duration: 2 years

64 credits

Soft Core courses: 21 credits (7 COURSES out of 9)
AS 202  3:0 Geophysical Fluid Dynamics
AS 203  3:0 Atmospheric Thermodynamics
AS 204  3:0 Atmospheric Radiation and Climate
AS 205  2:1 Ocean Dynamics
AS 207  3:0 Introduction to Atmospheric Dynamics
AS 210  3:0 Numerical methods in atmospheric modeling
AS 211  2:1 Observational Techniques
AS 215  3:0 Environmental Fluid Dynamics
AS 216  3:0 Introduction to Climate System

Mathematics Requirement: 3 credits (compulsory)
AS 209  3:0 Mathematical Methods in Climate Science
or
An equivalent Mathematics course offered by the Department of Mathematics, SERC, CDS, CEaS, or Department of Chemical Engineering

Project: 28 Credits
AS 299  0:28 Dissertation Project

Electives: 12 credits
The balance of 12 credits required to make up a minimum of 64 credits to complete the M.Tech Program.

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 :**

**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 215 (AUG) 3:0**

**Environmental Fluid Dynamics**


**Bishakhdatta Gayen**

**References :**
- *Buoyancy Driven Flow* Authors: J. S. Turner: Cambridge University Press, Published Date: 1979
- *Waves in the Ocean and Atmosphere: Introduction to Wave Dynamics* Authors: J. Pedlosky, Springer Verlag, Published Date: 2003

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

**Geophysical Fluid Dynamics**


**Jai Suhas Sukhatme, Debasis Sengupta**

**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 :
• Thomas T Warner,Numerical Weather and Climate Prediction,Cambridge University Press,2011,John B Drake

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 differenting, convergence and stability, testing and validation test Problems. P.N.Vinayachandran

Vinayachandran P N

References:
- Chassignet and Vernon J.(ED), Ocean Modeling and Parameterization.
Dept of Civil Engineering

Scheme of Instruction for M Tech Civil Engineering program (2020-21)

Semester 1 Common to all students
Core: 18 Credits
CE 201 3:0 Basic Geomechanics
CE 275:0 Transportation Systems Modelling
CE 217:0 Fluid Mechanics
CE 204:0 Solid Mechanics
CE 205:0 Finite Element Method (For the year 2020-21, this course is shifted to the February semester. It remains a core course for all MTech students, irrespective of their major)
CE 211:0 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 three Areas, a student must complete minimum of 12 credits in the said Area.

Major in Geotechnical Engineering
Core: 12 Credits (+ 3 credits from term 1)
CE 202:0 Foundation Engineering
CE 206:0 Earth and Earth Retaining Structures
CE 207:0 Geoenvironmental Engineering
CE 208:0 Ground Improvement and Geosynthetics
CE 299:0 22 Dissertation Project

Major in Structural Engineering
Core: 9 Credits (+ 6 credits from term 1)
CE 209:0 Mechanics of Structural Concrete
CE 210:0 Structural Dynamics
CE 228:0 Continuum Plasticity
CE 299:0 22 Dissertation Project

Major in Water Resources Engineering
Core: 12 Credits (+ 3 credits from term 1)
CE 203:0 Surface Water Hydrology
CE 213:0 Systems Techniques in Water Resources Engineering
CE 214:0 Ground Water Hydrology
CE 215:0 Stochastic Hydrology
CE 299:0 22 Dissertation Project

Major in Transportation Systems Engineering
Core: 12 Credits (+ 3 credits from term 1)
CE 269:0 Traffic Engineering
CE 262:0 Public Transportation Systems Planning
CE 272:0 Traffic Network Equilibrium
CE 235:0 Optimization Methods
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
CE 279 3:0 Computational Geotechnics

Electives in Structural Engineering

CE 216 3:0 Random Vibration and Reliability Analyses
CE 229 3:0 Non-Destructive Evaluation Methods for Concrete Structures
CE 234 3:0 Nonlinear analysis in earthquake engineering
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 257 3:0 Problems in the Mathematical Theory of Elasticity
CE 298 3:0 Parallel computing in mechanics problems

Electives in Water Resources Engineering

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
CE 277 3:0 Remote Sensing in Ecohydrology
AS 216 3:0 Introduction to Climate Systems

Electives in Transportation Systems Engineering

CE 271 3:0 Choice Modelling
CE 273 3:0 Markov Decision Processes
DS 290 3:0 Modelling and Simulation
ST 203 3:0 Technology and Sustainable Development
MG 221 3:0 Applied Statistics

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 204 (AUG) 3:0

Solid Mechanics

Introduction to tensor algebra and calculus, indicial notation, matrices of tensor components, change of basis formulae, eigenvalues, Divergence theorem. Elementary measures of strain. Lagrangian and Eulerian...

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 211 (AUG) 3:0
Mathematics for Engineers

Tarun Rambha, Debraj Ghosh

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 217 (AUG) 3:0

Fluid Mechanics

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

Dutta Debsunder

References :

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 234 (AUG) 3:0

Nonlinear Analysis in Earthquake Engineering


Manohar C S

Pre-requisites :
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 247 (AUG) 3:0
Remote Sensing and GIS for Water Resources Engineering

Nagesh Kumar D
References :

CE 248 (AUG) 3:0
Regionalization in Hydrology and Water Resources Engineering
Srinivas V V

References:

Pre-requisites:
• CE 203

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 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 275 (AUG) 3:0
Transportation Systems Modelling
Methods – Statistical and econometric methods for transportation data analysis; linear regression for analysis of continuous variable data (assumptions, estimation, specification, interpretation, hypothesis testing, segmentation, non-linear specification, testing of assumptions); discrete outcome models for analysis of categorical data (binary and multinomial choice models, maximum likelihood estimation); entropy methods for analysis of spatial flows; Demand-supply equilibrium; Models of traffic flow; Optimization models to predict traffic volumes. Applications – analysis of user behaviour in infrastructure systems; travel behaviour, travel demand and supply analysis (modelling the generation, spatial and temporal distribution, modal split, and route choice of travel); analysis of vehicular traffic streams; tools for data analysis and transport modelling.

Abdul Rawoof Pinjari

References:
CE 202 (JAN) 3:0
Foundation Engineering


TejasGorur Murthy

References :

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

CE 203 (JAN) 3:0
Surface Water Hydrology

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

Mujumdar P P

References :

CE 205 (JAN) 3:0
Finite Element Method


Chandra Kishen J M

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 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.

Srinivas V V

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


Nagesh Kumar D

References :
CE 222 (JAN) 3:0

Fundamentals of Soil Behaviour

Identification and classification of clay minerals, expansive and collapsing soils; Concepts and measurements of matric and osmotic suction, Role of inter-particle forces and suction in effective stress, Role of clay mineralogy, inter-particle forces and suction in volume change, hydraulic conductivity and shear strength of soils

Sudhakar Rao M, Raghuveer Rao P

Pre-requisites:


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 231 (JAN) 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 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:
• Lin, Y K, Probabilistic Structural Dynamics, McGraw-Hill
• 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 269 (JAN) 3:0
Traffic Engineering

Tarun Rambha
References:
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 Pijnjari

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 277 (JAN) 3:0
Remote Sensing in Ecohydrology

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

Dutta Debsunder

References:

CE 279 (JAN) 3:0
Computational Geotechnics

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

References:
- Highway Capacity Manual (2010), Transportation Research Board, USA.
References:
• Hai-Sui Yu, Plasticity and Geotechnics, Springer, 2006

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
Dept of Chemical Engineering

Courses in the Department : August 2020

<table>
<thead>
<tr>
<th>August Semester</th>
<th>January Semester</th>
</tr>
</thead>
<tbody>
<tr>
<td>CH 201 3:0 Engineering Mathematics</td>
<td>CH 205 3:0 Chemical Reaction Engineering</td>
</tr>
<tr>
<td>CH 202 3:0 Numerical Methods</td>
<td>CH 207 1:0 Applied Statistics &amp; 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 Fluids</td>
</tr>
<tr>
<td>CH 206 1:0 Seminar</td>
<td>CH 236 3:0 Statistical Thermodynamics</td>
</tr>
<tr>
<td>CH 235 3:0 Modelling in Chemical Engineering</td>
<td>CH 243 3:0 Mechanics of Particle Suspensions</td>
</tr>
<tr>
<td>CH 242 3:0 Special Topics in Theoretical Biology</td>
<td>CH 245 3:0 Interfacial and Colloidal Phenomena</td>
</tr>
<tr>
<td>CH 244 3:0 Treatment of Drinking Water</td>
<td>CH 247 3:0 Introduction to Molecular Simulations</td>
</tr>
<tr>
<td>CH 248 3:0 Molecular Systems Biology</td>
<td>CH 249 3:0 Structural and Functional DNA Nanotechnology</td>
</tr>
<tr>
<td>CH 299 0:32 Dissertation Project (M Tech)</td>
<td></td>
</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 core of 6 credits from the department offerings. The project work is equivalent of 32 credits.</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**


**Ananth Govind Rajan, 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 one of the instructors prior to registering for the course.

CH 202 (AUG) 3:0

Numerical Methods

Bhushan J Toley

References:

Pre-requisites:
- Graduate students (not open to UGs)

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 299 (AUG) 0:32

Dissertation Project
The ME project is aimed at training the students to analyze independently any problem posed to them. The project may theoretical, experimental, or a combination. In 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.

Venugopal S
CH 205 (JAN) 3:0

**Chemical Reaction Engineering**


**Venugopal S**

**References :**
- Ming, D., Glasser, D., Hildebrandt, D., Glasser, B., and Metzger, M., Attainable Region Theory– An Introduction to Choosing an Optimal Reactor
- Levenspiel, O., Chemical Reactor Omnibook
- Stewart, W. E., and Caracotsios, M., Computer-Aided Modeling of Reactive Systems
- Mory, M., Fluid Mechanics for Chemical Engineering
- Pangarkar, V. G., Design of Multiphase Reactors
- Ranade, V., Computational Flow Modeling for Chemical Reactor Engineering

**Pre-requisites :**
- Undergrad level CRE course

CH 207 (JAN) 1:0

**Applied statistics and design of experiments**

Overview of Applied Statistics; Introduction to Conditional Probability; Bayesian Inference for Parameter Estimation.

**Venugopal S**

**References :**
- Stewart, W. E., and Caracotsios, M., Computer-Aided Modeling of Reactive Systems

**Pre-requisites :**
- Undergraduate level CRE course

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 236 (JAN) 3:0

**Statistical Thermodynamics**

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

**Ganapathy Ayappa, Sudeep Punnathanam**

**References :**
CH 244 (JAN) 3:0

Treatment of drinking water

Availability of water; contaminants and their effects on human health; quality standards; removal of contaminants by various processes: chlorination, filtration, coagulation and flocculation, reverse osmosis, adsorption and ion exchange; rainwater harvesting; Sodis

Kesava Rao K

References:
- Droste, R. L., Theory and Practice of Water and Wastewater Treatment, Wiley (Asia) 2004
- World Health Organization 2017
- Current Literature

Pre-requisites:
- Droste, R. L., Theory and Practice of Water and Wastewater Treatment, Wiley (Asia) 2004
- Current Literature

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
MTech Program
Duration: 2 years
Total: 64 credits

Soft Core courses (4 out of 5)

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>ME201</td>
<td>3:0 Fluid Mechanics</td>
</tr>
<tr>
<td>ME228</td>
<td>3:0 Materials and Structure Property Correlations</td>
</tr>
<tr>
<td>ME240</td>
<td>3:0 Dynamics &amp; Control of Mechanical Systems</td>
</tr>
<tr>
<td>ME242</td>
<td>3:0 Solid Mechanics</td>
</tr>
<tr>
<td>ME271</td>
<td>3:0 Thermodynamics</td>
</tr>
</tbody>
</table>

(Soft Core) Math requirement

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>ME 261</td>
<td>3:0 Engineering Mathematics</td>
</tr>
<tr>
<td></td>
<td>OR</td>
</tr>
<tr>
<td>AE211</td>
<td>3:0 Mathematical Methods for Aerospace engineers</td>
</tr>
</tbody>
</table>

Seminar Course requirement

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>ME297</td>
<td>1:0 Seminar Course</td>
</tr>
</tbody>
</table>

Project: 27 Credits
ME2990: 27 Dissertation Project

Electives: 7 Courses (21 credits).

MTech (Res)
Duration: (min) 1 - 3 (max) years
Electives: (min) 12 - 21 (max) credits

(Soft Core) Math requirement

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>ME 261</td>
<td>3:0 Engineering Mathematics</td>
</tr>
<tr>
<td></td>
<td>OR</td>
</tr>
<tr>
<td>AE 211</td>
<td>3:0 Mathematical Methods for Aerospace engineers</td>
</tr>
</tbody>
</table>

Direct Ph.D. program
Duration: (min) 3 – 6 (max) years
Electives: (min) 24 – 33 (max) credits

(Soft Core) Math requirement

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>ME 261</td>
<td>3:0 Engineering Mathematics</td>
</tr>
<tr>
<td></td>
<td>OR</td>
</tr>
<tr>
<td>AE 211</td>
<td>3:0 Mathematical Methods for Aerospace engineers</td>
</tr>
</tbody>
</table>
Following successful completion of the RTP, the student will be eligible to appear for the comprehensive examination /general test provided they have secured CGPA (7/10) which is computed based on the basket rule based on the best grades for all courses that make-up the minimum RTP credit requirement. The comprehensive exam must be taken within 2 years from the date of registration. 1 semester of Teaching Assistantship (TA) is compulsory. No other specific requirements from the department aside from adherence to Institute policies.

**Ph.D. Program**

**Duration:** (min) 2 – 6 (max) years

Following successful completion of the RTP, the student will be eligible to appear for the comprehensive examination /general test provided they have secured CGPA (7/10) which is computed based on the basket rule based on the best grades for all courses that make-up the minimum RTP credit requirement. The comprehensive exam must be taken within 2 years from the date of registration. 1 semester of Teaching Assistantship (TA) is compulsory. No other specific requirements from the department aside from adherence to Institute policies.

A research student may credit courses in addition to the ones required for RTP. These are the non-RTP courses and maybe taken before or after the Comprehensive/General Test. There is no restriction on the number of such courses. Only courses with grades C or better will be listed in the transcript; these grades are not used for calculating the CGPA. RTP and non-RTP courses have to be chosen after careful consultation with the Research Supervisor/DCC. RTP and non-RTP courses cannot be interchanged after the registration.

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

**Fluid Mechanics**

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

*Ratnesh K Shukla, Aloe Kumar*

**Pre-requisites:**
- Kundu,P.K.,andCohen,I.M.,Fluid Mechanics

**ME 228 (AUG) 3:0**

**Materials and Structure Property Correlations**


*Koushik Viswanathan*

**Pre-requisites:**
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:
• Fung, Y.C., Foundations of Solid Mechanics, Prentice Hall.
• Srinath, L.S., Advanced Mechanics of Solids, Tata McGraw Hill.
• 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:
• c. s. jog

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

Scheme of Instruction 2020 - 2021
ME 255 (AUG) 3:0
Principles of Tribology

Bobji M S

Pre-requisites:

ME 260 (AUG) 3:0
Structural Optimization: Size, Shape, and Topology

Ananthasuresh G K

References:
- NPTEL MOOC: https://nptel.ac.in/courses/112/108/112108201/

Pre-requisites:
- Multivariable calculus and programming experience in MATLAB are preferred. Familiarity with finite element analysis is recommended.

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.

Gaurav Tomar, Koushik Viswanathan, Venkata R Sonti

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, Pradip Dutta, 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

ME 280 (AUG) 3:0
Fundamentals of nanoscale conduction heat transport
General introduction to the basic rules of quantum mechanics; crystal lattice definitions; reciprocal lattice; harmonic and anharmonic potential energy of the crystal; phonons as normal modes/eigenmodes of the crystal lattice vibrations; harmonic properties of the phonons - wavelength, wavevector, dispersions, group velocities and heat capacity; Einstein and Debye models; anharmonic phonon-phonon interactions; Fermi's golden rule and applications to phonons; anharmonic properties of phonons - phonon scattering rates, phonon lifetimes and phonon mean free paths; properties of the phonon-phonon collision matrix; momentum-conserving and momentum-dissipating scattering processes; Boltzmann equation for phonon transport; thermal conductivity; diffusive and non-diffusive heat transport.

Navaneetha Krishnan Ravichandran

References:

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 290 (AUG) 3:0

Mechanics of slender elastic structures

A graduate level course emphasizing geometrically nonlinear problems in structural mechanics. This class can be considered a logical sequence to previous courses on solid/continuum mechanics. Topics covered (in roughly chronological order) Linear elasticity solution for beams - Airy stress functions - Dependence of displacements/stresses/energies on slenderness ratio - Linear beam theories (Euler-Bernoulli beams) - Kinematic assumptions - Constitutive assumptions - Equilibrium - Comparison with linear elasticity solutions - Local differential geometry for planar curves - Regular parameterizations - Arc length as a limit of chord lengths - Tangents, normals and signed curvature - Fundamental theorem for plane curves - Nonlinear beam theories (Special Cosserat model) - Geometric description with base curves and directors - Kinematic assumptions, rotations of sections - Strain measures and interpretations - Equilibrium conditions - Linear constitutive relationship - Special problem: Elastica - Kinematic assumptions and corresponding parameterization of solutions - Equilibrium, exact solution and elliptic integrals - Analogy with pendulum - Qualitative solution features from phase portraits - Interpretation of phase portraits and solutions shapes - Stability - Three common notions of stability, min energy criterion - Directional derivatives - Energy functional, first and second variations - Equilibrium configurations, principle of virtual work - Sufficient condition for stability from second variations - Bifurcation points, stable and unstable branches - Examples with 1 and 2-dof systems - Linearized stability analysis, comparisons and examples - Stability of the elastica - Existence of energy functionals (Vainberg's theorem) - Solution of nonlinear algebraic equations - Newton's algorithm - Analysis of Newton's method: sufficient conditions for convergence and convergence rate - Interpretation of Newton's method as a fixed point iteration - Arc-length methods - Implementation aspects

Ramsharan Rangarajan

References:
- Shames & Dym, Energy and finite element methods in structural mechanics.
- Piero Villaggio, Mathematical models for elastic structures.
- Timoshenko, Theory of elastic stability

Pre-requisites:
- Preferably: Solid mechanics, finite element methods

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.

Koushik Viswanathan

Pre-requisites:
- Faculty Coordinator

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 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 254 (JAN) 3:0

Compliant Mechanisms

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

Ananthasuresh G K

References:
- NPTEL MOOC: https://nptel.ac.in/courses/112/108/112108211/
- Instructor’s notes.

Pre-requisites:
- Multivariable calculus and programming experience in MATLAB are preferred. Familiarity with kinematics and mechanisms is recommended.

ME 257 (JAN) 3:0

Finite Element Methods

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

Ramsharan Rangarajan

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:
- Meyer
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 284 (JAN) 3:0
Applied Combustion

Ravikrishna, R. V.

Pre-requisites:

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 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 (e.g., residual strains, shape tolerances). 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.

Dibakar Sen

References :
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.

ME 303 (JAN) 3:0
Partial Differential Equations with Applications


Gaurav Tomar, Venkata R Sonti

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

M. Tech in MATERIALS ENGINEERING
(Duration: 2 Years, 64 credits)

MTech students: 32 credit course work (Sem I and Sem II) + 32 credit dissertation (Sem III and Sem IV)
Minimum mandatory credits from courses within the department: 8 (3+3+2) credit hard core + 9 (3 +3+3) credits from among the basket of soft core + 9 credits from among the softcore/electives. The remaining 6 credits can be completed without restrictions (within or outside the department).

PhD students with M Tech background need to take a minimum of 12 credits and pass with minimum CGPA of 7.00. PhD students with BE/BTech/MSc degree must take a minimum of 24 credits and pass with a minimum CGPA of 7.0.

Students with BE/BTech/MSc degree joining the M Tech (Research) program or joining the PhD program and opting for additional M Tech (Research) degree are required to take minimum of 50 % of their total required credits from the basket of hard cores and soft cores offered by the department. This implies that students in M. Tech (Research) should take minimum 6 credits and students desirous of M. Tech (Research) degree together with PhD degree should take 12 credits from the basket of hard cores and soft cores.

(3 extra credits in MT 250 is mandatory for those who don't have a prior background in materials related discipline. This is a non-RTP course for PhD and M. Tech (Research) students which the student must pass with minimum C-grade.)

Hard core (8 credits)

MT 202  3:0  Thermodynamics and Kinetics
MT 241  3:0  Structure and Characterization of Materials
MT 243  0:2  Laboratory Experiments in Materials Engineering

Soft core (9 credits): At least three out of the following courses

MT 209  3:0  Defects in Materials
MT 213  3:0  Electronic Properties of Materials
MT 220  3:0  Microstructural Engineering of Structural Materials
MT 231  3:0  Interfacial Phenomenon in Materials Processing
MT 253  3:0  Mechanical Behaviour of Materials
MT 260  3:0  Polymer Science and Engineering
MT 271  3:0  Introduction to Biomaterials and Engineering

Project (32 credits)

MT 299  0:32  Dissertation Project

Electives (15 credits): At least 9 credits must be taken from the courses offered by the Department.

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.

Sai Gautam Gopalakrishnan
References:

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

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
- 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


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, CelulaAutomata.: 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 225 (AUG) 3:0
Deformation and Failure Mechanisms at Elevated Temperatures
Phenomenology of Creep, Microstructural considerations in metals, alloys, ceramics and composites. Creep mechanisms, Deformation mechanism maps, Superplasticity in metal alloys, ceramics and nanophase materials, Commercial applications and considerations, Cavitation failure at elevated temperatures by nucleation, growth and interlinkage of cavities.

Atul H Chokshi

References :

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

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

Govind S Gupta

References :
• F.M. White: Fluid Mechanics, McGraw Hill, 1994 Various research papers

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

Praveen Kumar

References :

Scheme of Instruction 2020 - 2021
MT 260 (AUG) 3:0
Polymer Science and Engineering
Fundamentals of polymer science: Polymer nomenclature and classification. Current theories for describing molecular weight, molecular weight distributions. Synthesis of monomers and polymers. Mechanisms of polymerization reactions. Introduction to polymer compounding and processing (for thermoplastic/thermosets). Structure, property relationships of polymers: crystalline and amorphous states, the degree of crystallinity, cross-linking, and branching. Stereochemistry of polymers. Instrumental methods for the elucidation of polymer structure and properties such as thermal (DSC, TGA, DMA, TMA, TOA), electrical (conductivity, dielectric), and spectroscopic (IR, Raman, NMR, ESCA, SIMS) analysis. GPC, GC-MS.

Suryasarathi Bose
References:
• Principles of Polymerization, George G Odian, John Wiley and Sons
• Textbook of Polymer Science, F. W. Bilmeyer, John Wiley and Sons
• F. W. Bilmeyer, John Wiley and Sons The Elements of Polymer Science and Engineering,

MT 261 (AUG) 3:0
Organic Electronics

Praveen C Ramamurthy
References:

MT 201 (JAN) 3:0
Phase Transformations

Chandan Srivastava
Pre-requisites:
MT 208 (JAN) 3:0
Diffusion in Solids

Aloke Paul

References:
- Paul G. Shewmon, Diffusion in Solids.

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

Elements of microstructure; Role of microstructure on properties; Review of crystalline defects; Methods of controlling microstructures: materials processing routes, heat treatments, phase transformations and mechanisms; Processing of cast and wrought alloys, Processing of nanostructured materials, processing of single crystals, Introduction to light metal alloys (Al-based, Mg-based and Ti-based), Introduction to high temperature superalloys, Introduction to high entropy alloys, Control of multiphase microstructures with case studies, hierarchical microstructures, composites; adaptive microstructures.

Surendra Kumar Makineni

References:
- David A Porter, K.E. Easterling, Phase transformations in metals and alloys, Chapman & Hall, 2nd edition, 1992

MT 231 (JAN) 3:0
Interfacial Phenomena in Materials Processing

Materials and surfaces, Adsorption from solution, Thermodynamics of adsorption - surface excess and surface free energy, Gibbs equation, adsorption isotherms, wetting, contact angle, Young's equation, Monolayer and interfacial reactions, Electrical phenomena at interfaces, electrochemistry of the double layer, electrokinetics, flocculation, coagulation and dispersion, Polymers at interfaces, Emulsions. Applications in Materials Processing.

Ashok M Raichur

References:
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 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
Review of elastic and plastic deformation, Historical development of fracture mechanics, Thermodynamics of fracture including Griffith theory, Linear elastic fracture mechanics, Irwin and Dugdale extensions, Stability of cracks, Crack resistance curves and toughening of brittle materials, Ductile failure, J-integral, Introduction to FEM and its applications to fracture mechanics, Indentation failure, Environmental aspects of failure, Thermal stresses, Cyclic Fatigue, Methods to measure toughness.

Praveen Kumar, Vikram Jayaram

References :
MT 257 (JAN) 3:0
Finite Element Method for Materials Engineers
This course has been specially designed for those students, who did not get a chance to study FEM during undergrad, but want to use FEM as a tool to gain some insight into their project/research problems. The syllabus includes the following: Quick recap of relevant mathematical concepts. Introduction to fundamentals of elasticity and plasticity. Crystal plasticity. Philosophy of FEM. Fundamentals of FEM, such as concepts of meshing, stiffness matrix, interpolation functions. Residual methods, Rayleigh - Ritz method, Galerkin method. 1-D, 2-D and 3-D example problems in elasticity and heat transfer. Solving linear and non-linear structural, thermal and electrical problems using a commercial FEM software (mostly, ANSYS). Finite element crystal plasticity.

Praveen Kumar

References:

MT 262 (JAN) 3:0
Concepts in Polymer Blends and Nanocomposites
Introduction to polymer blends and composites, nanostructured materials and nanocomposites, Polymer-polymer miscibility, factors governing miscibility, immiscible systems and phase separation, Importance of interface on the property development, compatibilizers and compatibilization, Blends of amorphous & semi-crystalline polymers, rubber toughened polymers, particulate, fiber reinforced composites. Nanostructured materials like nano clay, carbon nanotubes, graphene etc. and polymer nanocomposites. Surface treatment of the reinforcing materials and interface/interphase structures of composites / nanocomposites. Various processing techniques like solution mixing, melt processing. Unique properties of blends, composites/nanocomposites in rheological, mechanical, and physical properties and applications.

Suryasarathi Bose

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
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
## 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>
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<tr>
<td>PD 202</td>
<td>2:1</td>
<td>Elements of Solid and Fluid Mechanics</td>
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<tr>
<td>PD 203</td>
<td>2:1</td>
<td>Creative Engineering Design</td>
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<td>PD 205</td>
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<td>Materials, Manufacturing and Design</td>
</tr>
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<td>PD 207</td>
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<td>Product Visualization, Communication and Presentation</td>
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<td>PD 209</td>
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<td>New Product Development: Concepts and Tools</td>
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<td>PD 211</td>
<td>2:1</td>
<td>Product Design</td>
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<tr>
<td>PD 212</td>
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<td>Computer Aided Design</td>
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<td>PD 215</td>
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<td>Mechatronics</td>
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<td>PD 216</td>
<td>2:1</td>
<td>Design of Automotive Systems</td>
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<td>PD 217</td>
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<td>CAE in Product Design</td>
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<td>PD 218</td>
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<td>New Product Development: Strategy and Practice</td>
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<td>PD 221</td>
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<td>Methodology for Design Research</td>
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<td>PD 229</td>
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<td>PD 231</td>
<td>2:1</td>
<td>Applied Ergonomics</td>
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<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>
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<td>PD 234</td>
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<td>Intelligent User Interface</td>
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<td>PD 235</td>
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<td>PD 236</td>
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<td>Embodiment Design</td>
</tr>
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<td>Design and Society</td>
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### Project: 16 Credits. This is mandatory for all

<table>
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<tr>
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<tr>
<td>PD 299</td>
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<td>Dissertation Project</td>
</tr>
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</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>CourseCode</th>
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<tr>
<td>MN 201</td>
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<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>CourseCode</th>
<th>Credits</th>
<th>CourseName</th>
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</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>
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</table>

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

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<th>CourseCode</th>
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<th>CourseName</th>
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<tbody>
<tr>
<td>EO 259</td>
<td>3:1</td>
<td>Data Analytics</td>
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<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>
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</tbody>
</table>

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

<table>
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<tr>
<th>CourseCode</th>
<th>Credits</th>
<th>CourseName</th>
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</thead>
<tbody>
<tr>
<td>MN 208</td>
<td>0:28</td>
<td>Dissertation Project</td>
</tr>
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</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.

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

References:

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


Dibakar Sen, Ashitava Ghosal, Gurumoorthy B

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

**MN 206 (AUG) 0:28**  
**Final Project**

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

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

Pre-requisites:
- Completed all ten courses mandatory for MTech Smart Manufacturing programme in its first and second terms.

**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**:

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

PD 207 (AUG) 1:2

**Product Visualization, Communication and Presentation**

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

**Shivakumar N D**

**References**:

- Geometry of design: Studies in proportion and composition, ISBN : 1568982496,
- Foundation of Art & Design 1856693759,

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**:

- (1) Ulrich, K.T., and Eppinger, S.D., Product Design and Development, 2nd edition,
- (2) Philip Kotler, Kevin Lane Keller, Marketing Management, 15th edition,
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 Definition and Classification, Bioethics and Privacy, 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, Biocompatibility and Biomaterials Testing, Clinical Trials, Digital Healthcare, 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 :

PD 239 (AUG) 0:3
Design and Society

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

Dibakar Sen
Centre for Sustainable Technologies

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 216 (AUG) 3:0

Physics in Experiments with Classical Statistics

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

Punit Singh

References:

Pre-requisites:
- Mathematics (12 grade and above); Interpreting physical phenomena; Conversant with measurement, experimental and field studies

ST 217 (AUG) 3:1

Field hydrology, river engineering and basin studies

This course is an integrated package that aims to map both perennial and semi-perennial surface flows in Bastar region of Chhattisgarh state using information of rainfall, topography, surface flows and sub-surface water dynamics with an aim to create a sustainability of water resources management. A non-intrusive aquifer investigation and time scale studies of under-ground gradient towards the valleys is envisaged. Origin of springs from where these streams have evolved will be studied and along with longitudinal surface gradient understanding both its influent and effluent relationship with groundwater. The tribal settlements, their water needs for irrigation and drinking water using surface water flows and natural hydropower (non-electricity) or renewable energy-based pumping will be studied. Options of sub-surface storage (provided as natural aquifer is identified) as well as surface water storage will be studied over the entire topography of Bastar region. Pumped storage for electricity and water requirements will be envisaged for regions that are not in the vicinity of streams. Ecological preservation interfaced with meeting the local needs will be stressed. Further, river morphology and sediment behavior will be investigated for any created obstruction of flow (either diversion of weir or riverbed foundations structure that may rise during activities). Overall modelling and sustainability with both waterpower and other renewable energy sources will be the objective.

Punit Singh

References:
Centre for Earth Sciences

The Centre for Earth Sciences offers three post-graduate courses: (i) Ph.D., (ii) M.Tech. (Research) and (ii) M.Tech. in Earth Sciences.

The Ph.D. students can take any of the courses offered in the department as well as in other department after consulting with their Ph.D. supervisor. Students with a B.Tech./ M.Sc. degree must finish 24 credits while students with an M.Tech. degree must finish 12 credits. M.Tech. (Research) students can take any of the courses offered in the department as well as in other department after consulting with their Ph.D. supervisor.

M.Tech. students have to complete 64 credits in two years. Students must take all 8 ‘hard core’ courses (total 24 credits) listed below. In addition they must take 5 elective courses (15 credits) out of which 3 courses (9 credits) must be from the elective courses listed below. The M.Tech. project has 25 credits.

M Tech Programme in Earth Science
Duration: 2 years: 64 Credits

Hard Core: 24 Credits (All courses are mandatory)

ES 203:0 Introduction to Petrology (AUG)
ES 204:0 Origin and Evolution of the Earth (AUG)
ES 205:0 Mathematics for Geophysicists (AUG)
ES 206:0 Solid Earth Geophysics (AUG)
ES 215:0 Introduction to Chemical Oceanography (AUG)
ES 201:2:1 Introduction to Earth System Science (JAN)
ES 217:3:0 Fundamentals of Geophysics (JAN)
ES 207:0:3 Earth Science Laboratories (JAN)

Electives: 15 Credits of which at least 9 credits must be from among the group electives listed below.

ES 208:3:0 Mantle Convection (JAN)
ES 209:3:0 Biogeochemistry (AUG)
ES 211:3:0 Applied Petrology (JAN)
ES 212:3:0 Fluid dynamics of planetary interiors (JAN)
ES 213:3:0 Isotope Geochemistry (JAN)
ES 216:3:0 Advanced Chemical Oceanography (JAN)
CE 247N:3:0 Remote Sensing and GIS for Water Resources & Environmental Engineering (JAN)

Project: 25 Credits

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

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

Binod Sreenivasan

References:
- Panton, R.L., Incompressible flows, John Wiley & Sons, 2006
- Lecture notes

ES 206 (AUG) 3:0

Solid Earth Geophysics

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

Attreyee Ghosh

References:

ES 215 (AUG) 3:0

Introduction to Chemical Oceanography

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

Sambuddha Misra

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

ES 201 (JAN) 2:1

Introduction to Earth System Science

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

Prosenjit Ghosh

References:

ES 207 (JAN) 0:3

Earth Science Laboratory

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

Sambuddha Misra, Ramananda Chakrabarti, Binod Sreenivasan, Attreyee Ghosh, Prosenjit Ghosh, Kusala Rajendran, Sajeev Krishnan

References:
- Techniques in sedimentology edited by Maurice Tucker, Black Scientific Publications, 1988

Pre-requisites:
- Student must have credited ES 201, 203, 204

ES 208 (JAN) 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:


ES 211 (JAN) 3:0
Applied Petrology
Sajeev Krishnan

ES 212 (JAN) 3:0
Fluid dynamics of planetary interiors
Basic fluid dynamics - Navier-Stokes equation, vorticity equation, Kelvin's circulation theorem, energy and dissipation, helicity. Rotation - Coriolis force, linear inertial waves, formation of Taylor columns, geostrophy, quasi-geostrophic approximation. Stratification - Gravity waves, effect of rotation, Braginsky's theory of stratified outer core of the Earth. Magnetic fields - Magnetohydrodynamic (MHD) equations, Lorentz force, low and high magnetic Reynolds number, Alfvén waves, Magnetic-Coriolis (MC) waves, Rayleigh Benard convection with magnetic field and rotation, MHD of planetary cores. Turbulence - Richardson's cascade, overview of classical theories, 2D turbulence, turbulence under moderate and rapid rotation, MHD turbulence, different length scales in planetary core turbulence.

Binod Sreenivasan

References:

- Journal papers

ES 213 (JAN) 3:0
Isotope Geochemistry
Nuclear systematics; decay mode of radionuclides; radioactive decay; Rb-Sr, Sm-Nd, Lu-Hf, Re-Os and U-Th-Pb systematics, U series disequilibrium, stable isotope fractionation, early Solar System processes, crust-mantle processes, aquatic processes, selected mass spectrometry techniques.

Ramananda Chakrabarti

References:

- Alan P. Dickin, Radiogenic Isotope Geology, Cambridge University Press, 1995
- Gunter Faure and Teresa M. Mensing, Isotopes - principles and applications 3rd edition, Wiley-India Edition

ES 216 (JAN) 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:

- (1) Tracers in the Sea – Broecker and Peng, LDEO Press, 1983
- (2) CO2 in Seawater – Zeebe and Wolf-Gladrow, Elsevier Oceanography Series, 2003
ES 217 (JAN) 3:0

Fundamentals of Geophysics

Structure of the Earth’s interior - density, seismic velocity, pressure and temperature dependence. Earth’s magnetic field - the dynamo process, paleomagnetism, geomagnetic reversals. Plate motions - absolute and relative motions, Euler poles, triple junction, simple calculations. Elements of potential field theory and applications, Earth’s gravity field, geodesy, isostasy, Plate tectonics, earthquake and faulting processes, types of faults and relation to stress fields, moment tensors and earthquake focal mechanisms

Binod Sreenivasan, Attreyee Ghosh

References:

ES 299 (JAN) 0:25

Dissertation Project

MTech thesis dissertation

Sambuddha Misra, Ramananda Chakrabarti, Binod Sreenivasan, Attreyee Ghosh, Prosenjit Ghosh, Kusala Rajendran, Sajeev Krishnan
Preface

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

BE  Centre for Biosystems Science & Engineering
CP  Robert Bosch Centre for Cyber Physical Systems
ER  Interdisciplinary Centre for Energy Research
DS  Department of Computational and Data Sciences
MG  Department of Management Studies
MS  Interdisciplinary Mathematical Sciences
NE  Centre for Nano Science and Engineering
UP  Centre for Infrastructure, Sustainable Transportation and Urban Planning

The first two digits of the course number have the departmental code as the prefix. 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. Navakanta Bhat
Dean
Division of Interdisciplinary Research
BioSystems Science and Engineering

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

<table>
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<tr>
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<td>BE 203</td>
<td>0:1</td>
<td>Bioengineering practicum 1</td>
</tr>
<tr>
<td>BE 204</td>
<td>0:1</td>
<td>Bioengineering practicum 2</td>
</tr>
<tr>
<td>BE 207</td>
<td>3:0</td>
<td>Mathematical Methods for Bioengineers</td>
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<tr>
<td>BE 213</td>
<td>2:0</td>
<td>Fundamentals of Bioengineering 1</td>
</tr>
<tr>
<td>BE 214</td>
<td>2:0</td>
<td>Fundamentals of Bioengineering 2</td>
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Soft core (for students from engineering background who have not taken Biology after school)

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<tr>
<th>Course Code</th>
<th>Credits</th>
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</tr>
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<tbody>
<tr>
<td>BE 206</td>
<td>3:0</td>
<td>Biology for Engineers</td>
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</table>

Electives offered by department

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<tr>
<th>Course Code</th>
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<td>BE 202</td>
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<td>Thermodynamics and Transport in Biological Systems</td>
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<tr>
<td>BE 209</td>
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<td>Digital Epidemiology</td>
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<tr>
<td>BE 210</td>
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<td>Drug Delivery</td>
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<tr>
<td>BE 212</td>
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<td>Research Communications</td>
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**BE 202 (AUG) 3:0**

**Thermodynamics and Transport in Biological Systems**

Transport: Introduction to biological flow systems, passive & active transport, Heat, Mass and Momentum Transfer with Case Studies. This part will be taught by Dr Priya Gambhire (Inspire Faculty, BSSE, IISc) Thermodnamic: First and Second Laws, Heat and Work Interactions, Application to Open Systems, Lattice Models and Binding Equilibria, Regular Solution Theory, Phase and Reaction Equilibria, Membrane Biophysics. This part will be taught by Prof. Ganapathy Ayappa (Chemical Engineering, IISc)

**Ganapathy Ayappa**

**References:**
- Introduction to Chemical Engineering Thermodynamics: Special Indian Edition by J. M. Smith, H.C. Ness, M. Abbott and B Bhatt

**Pre-requisites:**
- Some background in basic heat, mass and momentum preferred. Undergraduate level thermodynamics.
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

References:

BE 209 (AUG) 1:0

Digital Epidemiology

Epidemiology is the study of health and disease in populations. The sudden and savage nature of the ongoing COVID-19 pandemic has certainly caught everyone’s attention. The fact that it has happened when the globe is so well connected thanks to information technology has made epidemiologists of just about anyone who has some mathematical ability and appreciation of infectious disease dynamics. However, there are some serious mathematicians and data scientists who have been interested in the power of computational epidemiology in counterfactual reasoning and in the predictive power of data driven models. The prediction by the Global Virome Project that we could have around three zoonotic episodes a year that would have pandemic potential implies that we do need the best minds to help us prepare for the next one. Previous course offerings are archived at the website http://healtheatmapindia.in/digita-epidemiology. Syllabus: Introduction to epidemiology; SIR modelling, from the microscopic to the macroscopic, herd immunity; Compartment models (location compartments, age compartments, disease stage compartments), impact on herd immunity, social distancing, masks; Parameter fitting for SIR models; Clinical studies and disease biology. Agent-based models - general description, network generation and computational aspects, contact tracing, transport, calibration, validation. Data-driven and mathematical modeling for response is going to be specific to the stages of a pandemic – pre-pandemic, acceleration, mitigation, suppression and post-pandemic (peace time). Instructor: This course will be taught by Prof. Vijay Chandru (vijaychandru@iisc.ac.in), Adjunct Professor, BSSE

Narendra M Dixit

References:
- Statistical models in Epidemiology, D. Clayton and M. Hills, Oxford University Press
- Data-driven modeling for different stages of pandemic response

Pre-requisites:
- The only prerequisite for this course is a reasonable preparation in computational mathematics – modelling and analysis
BE 210 (AUG) 3:0

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: Engineering Principles for Drug Therapy, W. Mark Saltzman, Oxford University Press, 2001
• Drug Delivery: Fundamentals and Applications, Anya M. Hillery and Kinam Park

Pre-requisites:
• Open for all PhDs. Undergraduates must have finished two years of UG curriculum

BE 214 (AUG) 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.

Siddharth Jhunjhunwala, Ananthasuresh G K

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

Pre-requisites:
• Two course in mathematics at the undergraduate level
• For undergraduates interested in this course, they must have completed 2 years in the IISc undergraduate program

BE 203 (JAN) 0:1

Bioengineering Practicum 1

Bioengineering Practicum provide bioengineering laboratory experience to enable the student to do practical work in a particular field of specialization by working in the laboratories of the thesis adviser(s). The student is expected to learn the experimental techniques and practical methods pertaining to the research topic undertaken. The student is also expected to understand his/her thesis project and should be able to explain its significance in the field. They are also expected to have started performing research in the lab and understand the principles behind the experiments being conducted. The evaluation will be based on written reports and oral presentation. 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 thesis research. The students are advised to take the initiative to thoroughly understand all the related material of each and every technique and experiment they learn and perform.

Rachit Agarwal, Narendra M Dixit

Pre-requisites:
• Admission into BSSE PhD. program
BE 204 (JAN) 0:1

Bioengineering Practicum 2

Bioengineering Practicum provide bioengineering laboratory experience to enable the student to do practical work in a particular field of specialization by working in the laboratories of the thesis adviser(s). The student is expected to learn the experimental techniques and practical methods pertaining to the research topic undertaken. The student is also expected to understand his/her thesis project and should be able to explain its significance in the field. They are also expected to have started performing research in the lab and understand the principles behind the experiments being conducted. The evaluation will be based on written reports and oral presentation. 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 thesis research. The students are advised to take the initiative to thoroughly understand all the related material of each and every technique and experiment they learn and perform.

Rachit Agarwal, Narendra M Dixit

Pre-requisites :
• Admission into the BSSE PhD program

BE 207 (JAN) 3:0

Mathematical Methods for Bioengineers

Linear algebraic equations; Existence and uniqueness of solutions; LU factorization; Linear least squares; Eigenvalues and eigenvectors; QR iteration; Nonlinear equations; Fixed point iteration; Optimization methods; Nonlinear least squares; Ordinary differential equations; First and second order ODEs; Euler, RK4, and predictor-corrector methods; Basic probability and statistics; Hypothesis testing; Student’s t-test; ANOVA; Non-parametric tests

Mohit Kumar Jolly, Narendra M Dixit

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 213 (JAN) 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, the enzyme electrode, chemistries for the detection of proteins/polypeptides and nucleic acids; microfluidics and its applications in biosensing; fluid dynamics and chemical kinetics of microfluidic biosensors; introduction to point-of-care biosensing; lateral flow assays, systems engineering approach in designing sample-in-answer-out biosensors

Bhushan J Toley, Mohit Kumar Jolly
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
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

Revisit to Digital Image and Video Processing, Camera Models, Background Modelling, Object Detection and Recognition, Local Feature Extraction, Biologically Inspired Vision, Object Classification, Segmentation, Object...
Tracking, Activity Recognition, Anomaly Detection, Handling Occlusion, Scale and Appearance changes, Other Applications.

Venkatesh Babu R, Anirban Chakraborty

References:
- Current Literature

Pre-requisites:
- Image Processing, Probability, Linear Algebra

DS 284 (AUG) 2:1
Numerical Linear Algebra

Phani Sudheer Motamarri

Pre-requisites:
- Basics of matrix algebra, Basic programming, Vectors and vector spaces

DS 288 (AUG) 3:0
Numerical Methods

Sashikumaar Ganesan

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
and simulation concepts, Discrete-event simulation: Event scheduling/Time advance algorithms verification and validation of simulation models. Continuous Simulation: Modelling with and Simulation of Stochastic Differential Equations.

**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 250 (JAN) 3:1**

**Multigrid Methods**


**Sashikumaar Ganesan**

**Pre-requisites:**
- Good Knowledge of Linear Algebra and/or consent from the instructor.

**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.

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Scheme of Instruction 2020 - 2021
**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/](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 323 (JAN) 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 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, Deepak Subramani**

**References :**
- Edward Ott, Chaos in Dynamical Systems, Camridge 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.

**Pre-requisites :**
- Consent from Advisor, Good knowledge of basic mathematics, Basics of data science.
Nanoscience and Engineering

M Tech Degree Programme

Duration: 2 years

Departmental Core 11 credits

Course Credits & Title

NE 200 2:0 Technical Writing and Presentation
NE 201 2:1 Micro and Nano Characterization
NE 202 0:2 Micro and Nano Fabrication
NE 203 3:0 Advanced micro- and nanofabrication technology and process
NE 250 1:0 Entrepreneurship, Ethics and Societal Impact

Project
NE 299 0:27 Project Work
0:03 May-July
0:09 August–December
0:15 January June

Electives: The balance of 26 credits to make up the minimum of 64 credits required to complete the M Tech Programme at CeNSE has to be taken by choosing elective courses from within/outside the department with the approval of the Faculty advisor such that at least 4 elective courses have to be chosen from CeNSE.

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
- Sorab K. Gandhi, VLSI Fabrication Principles: Silicon and Gallium Arsenide
- Richard C. Jaeger, Introduction To 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

Akshay K Naik, Shivashankar S A

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 fluids. Transport in fluids, equations of change, flow at micro-scale, hydraulic circuit analysis, passive scalar transport, potential fluid flow, stokes flow Electrostatics and electrodynamics, electroosmosis, electrical double layer (EDL), zeta potential, species and charge transport, particle electrophoresis, AC electrokinetics, Surface tension, hysteresis and elasticity of triple line, wetting and long range forces, hydrodynamics of interfaces, surfactants, special interfaces, Suspensions, rheology, nanofluidics, thick-EDL systems, DNA transport and analysis.

Prosenjit Sen

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

NE 241 (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
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 don'ts 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 student 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.

Akshay K Naik, Manoj Varma

Pre-requisites:
- Lecture notes and hands-on training manuals.

**NE 202 (JAN) 0:2**

**Micro AND Nano Fabrication**

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

Shankar Kumar Selvaraja, Sushobhan Avasthi

Pre-requisites:
- NE203

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

Prosenjit Sen

References :

NE 223 (JAN) 2:1

Analog Circuits and Embedded System for Sensors


Saurabh Arun Chandorkar

Pre-requisites :
• 1st/2nd year undergraduate level Basic Circuits course, 1st/2nd year undergraduate level Basic Programming course

NE 299 (JAN) 0:27

Dissertation Project

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 332 (JAN) 3:0
Physics and Mathematics of Molecular Sensing
This course presents a systematic view of the process of sensing molecules with emphasis on bio-sensing using solid state sensors. Molecules that need to be sensed, relevant molecular biology, current technologies for molecular sensing, modeling adsorption-desorption processes, transport of target molecules, noise in molecular recognition, proof-reading schemes, multi-channel sensing, comparison between in-vivo sensing circuits and solid state biosensors

Manoj Varma
Pre-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. --
Dept of Management Studies

Master of Management (M.Mgt) Program

Duration: 2 years

Hard Core: 24 credits
- MG201 3:0 Managerial Economics
- MG211 3:0 Human Resource Management
- MG212 2:1 Behavioral Science
- MG221 2:1 Applied Statistics
- MG232 3:0 Principles of Management
- MG241 3:0 Marketing Management
- MG251 3:0 Finance & Accounts
- MG261 3:0 Operations Management

Stream Core: 12 Credits (to be chosen from either one of the two streams)

Stream 1: Business Analytics Stream
- MG223 3:0 Applied Operations Research
- MG225 3:0 Decision Models
- MG226 3:0 Time Series Analysis and Forecasting
- MG265 2:1 Data Mining

Stream 2: Technology Management Stream
- MG271 3:0 Technology Management
- MG274 3:0 Management of Innovation and Intellectual Property
- MG281 3:0 Management of Technology for Sustainability
- MG298 2:1 Entrepreneurship for Technology Start-ups

Electives: 12 credits

Project: MG2990: 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 212 (AUG) 2:1**

**Behavioral Science**

Understanding human behaviour; functionalist, cognitive, behaviouristic and social learning theories; perceiving; 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 :**

Scheme of Instruction 2020 - 2021
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 258 (AUG) 3:0
Financial instruments and risk management strategies
The purpose of this course is to introduce various financial instruments, such as futures, options, and swaps associated with different asset classes, such as interest rates, forex and stocks. The course covers the principles of derivative pricing with an introduction to the Black Scholes framework. We cover some basic hedging strategies including delta hedging to manage derivative risks. Basic numerical schemes for derivative pricing, bootstrapping of interest rate term structure are also covered.

Shashi Jain
References:
•  Options, Futures, and Other Derivatives (John Hull). Pearson.

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:

FL 141 (JAN) 3:0

Preliminary Course in Russian

Phonetics, speech patterns, tables, lexical and grammatical exercises and dialogues

Yadnyvakya

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.

Parthasarathy Ramachandran

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

MG 222 (JAN) 3:0

Regression and Time Series Analysis


Mukhopadhyay C

References:

Scheme of Instruction 2020 - 2021
MG 223 (JAN) 3:0
Applied Operations Research

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

MG 226 (JAN) 3:0
Advanced Analytics

Mukhopadhyay C
References :

MG 251 (JAN) 3:0
Finance and Accounts

Shashi Jain
Pre-requisites :
• Horngren, Foster and Dattar, Cost Accounting, PHI Publication, Tenth Edition.

Scheme of Instruction 2020 - 2021
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 carry out individual project works.

Parthasarathy Ramachandran
**CYBER PHYSICAL SYSTEM**

**CP 212 (AUG) 2:1**  
**Design of Cyber-Physical Systems**

This course will be taught jointly with Dr. Ashish Joglekar and Darshak Vasavada. This is an interdisciplinary course on the design of cyber-physical systems, inviting students from all the departments. It provides an in-depth exposure to various elements of a CPS: the microprocessor, interfacing physical devices (analog and digital) and control systems basics. This course uses a practical approach and involves significant programming.  

**Syllabus:**  
1. Microprocessor system  
2. Interfacing physical devices  
3. Control system basics  
4. EMI/EMC considerations  
5. Network connectivity  

**Bharadwaj Amrutur**

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

**Pre-requisites:**  
- C programming  
- Familiarity with any microprocessor and analog/digital circuits

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**CP 214 (AUG) 3:1**  
**Foundations of Robotics**

NOTE: This course is cross-listed with CSA (soft core for CSA)  

**Motivation and objective:** As we see an increasing use of industrial and service robots around us, there is a need for development of new skills in the field of robotic systems. More importantly, there is a need for development of new expertise in controllers, systems, sensors and algorithms that are tailored for the domain of robotic systems. Therefore, the objective of this course is to serve as an introductory robotics course for EECS students with little/no background in mechanical systems. The course will first build the necessary mathematical framework in which to understand topics relevant to fundamentals of mechanical systems. Some of the topics are center of gravity and moment of inertia, friction, statics of rigid bodies, principle of virtual work, kinematics of particles and rigid bodies, impacts, Newtonian and Lagrangian mechanics. With these fundamentals, the course will focus on topics like rigid body transformations, forward and inverse kinematics of manipulators, and forward and inverse dynamics of manipulators. Towards the end of the course advanced topics such as rigid body collisions, and hybrid dynamical systems will also be covered.  

**Syllabus:**  

**Shishir N Y**

**References:**  
- Murray, Li and Sastry, A Mathematical Introduction to Robot Manipulation, CRC Press, 1994  

**Pre-requisites:**  
- None

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**CP 311 (AUG) 2:1**  
**Dynamics and Control of Smart Materials**

This course will be taught jointly with Josephine Selvarani Ruth D  

**Syllabus:** Introduction to smart/intelligent materials, artificial intelligence vs embedded inherent intelligence smart systems, definitions and implications, components of smart systems, role of smart materials in developing active intelligent systems. Dynamics of high bandwidth low strain smart systems (piezoelectrics, magnetostrictive), types of piezoelectric materials, generator
and motor principle, constitutive relationship, unimorph and bimorph actuators, design of sensing and actuating smart systems, application examples. Dynamics of high strain low bandwidth systems (shape memory alloys, electro-active polymers, magnetostrictive, electrostrictive), phase transformations, characteristics of SMA control, modelling approach, Design of actuators – damper, compliant, variable impedance actuator, self-sensing actuator, application examples. Design and control of hybrid smart systems (System identification, controller, MATLAB Simulink), Intelligent system design, factors to be considered in selection of smart materials to develop a smart systems, optimal placement, dynamics of smart hybrid system, modelling features, concepts of sensor – actuator integration, amalgamation of smart materials and control system. Shared sensing and actuation, self-sensing actuation, techniques of dual functionality, developing a smart device in a networking dual control loop systems. Laboratory experiments on the above topics

Bharadwaj Amrutur

References:
• Culshaw B., Smart structures and Materials, Artech house, 1996
• Srinivasan A.V., Michael McFarland D., Smart Structure analysis and design, Cambridge University Press, 2001

Pre-requisites:
• Basic undergraduate engineering Courses

CP 314 (JAN) 3:1

Robot Learning and Control

NOTE: This course is cross-listed with E1 301 (soft-core at CSA)  Motivation and objective: This graduate course will explore the new area of interaction between learning and control specifically applied to robotic systems, both from a foundational level together with a view toward application. The course will first build the necessary framework in which to understand robotic systems, including robot kinematics and dynamics, sensing and estimation, machine learning and control. With these fundamentals the course will focus on data driven approaches for control. Syllabus: Robot dynamics and kinematics, nonlinear control and stability, Lyapunov theory, PD control, reinforcement learning, imitation learning, model-based and model-free methods, impedance control, trajectory optimization, online learning.

Shishir N Y, Shalabh Bhatnagar

References:
• S. Levine, Deep Reinforcement Learning.

Pre-requisites:
• E0 226 Linear Algebra and Probability or equivalent