Scheme of Instruction

Academic Year 2021-22

Part-A
(August Semester)

Index

Preface

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

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

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

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

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

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

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

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

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

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 such as biology, chemistry, physics and medicine are admitted into the Division for research work leading to a PhD degree.

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

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

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

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

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

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

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

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

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

Prof. Usha Vijayaraghavan

Dean,

Division of Biological Sciences

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	BiophysicalChemistry
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)

DB 202 (AUG) 2 : 0

General Biology

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

Renee M Borges

Pre-requisites : None

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

Biochemistry

BC 201 (AUG) 2 : 0

Cell Biology

Biogenesis of proteins in eucaryotes: targeting to intracellular organelles, post-translational modifications, cellular redox. Intracellular protein degradation: lysosomal and non-lysosomal. Nuclear organization and function, chromosome structure, function and inheritance. Regulation of the Cell cycle, dynamic molecular events during mitosis, cell-cell communication.

Utpal Tatu , Dipankar Nandi , Saravanan Palani

Pre-requistes : None :

References

BC 202 (AUG) 2 : 0

Proteins: Structure and Function

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

Mahipal Ganji

Pre-requistes : None

References : None

BC 203 (AUG) 3 : 0

General Biochemistry

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

Debabrata Laha

Pre-requistes : None

References : None

BC 306 (AUG) 3 : 0

Essentials in Immunology

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

Dipankar Nandi , Kesavardana Sannula

Pre-requistes : None

References : None

Ecological Sciences

EC 301 (AUG) 2 : 1

Animal Behaviour : Mechanisms and Evolution

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

Rohini Balakrishnan , Maria Thaker

Pre-requistes : None

References : None

EC 302 (AUG) 2 : 1

Plant-Animal Interactions (Ecology, Behaviour and Evolution)

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

Renee M Borges

Pre-requistes : None

References : None

EC 303 (AUG) 2 : 1

Stochastic and Spatial Dynamics in Biology

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

Vishwesha Guttal

Pre-requistes : None

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

EC 305 (AUG) 2 : 1

Quantitative Ecology : Research Design and Inference

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

Kavita Isvaran

Pre-requistes : None

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

EC 101 (AUG) 1 : 0

Process of Scientific Thinking

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

Maria Thaker

Pre-requistes : None

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

EC 202 (AUG) 2 : 0

Ecology: Pattern and Process

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

Kartik Shanker , Umesh Srinivasan

Pre-requistes : None

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

Neuroscience

NS 201 (AUG) 2 : 0

Systems Neuroscience

Neuronal biophysics, sensation & perception, motor systems

Aditya Murthy , S P Arun , Supratim Ray

Pre-requistes : None

References :
Kandel & Schwartz, Principles of Neural Science, 5th Edition

NS 202 (AUG) 2 : 0

Molecular and Cellular Basis of Behaviour

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

Balaji J , Deepak Kumaran Nair

Pre-requistes : None

References : None

NS 203 (AUG) 2 : 0

Cognitive Neuroscience

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

Sridharan Devarajan , Srikanth Padmala

Pre-requistes : None

References : None

NS 204 (AUG) 2 : 0

Developmental Neuroscience

Basic neuroanatomy of the central and peripheral nervous systems, neurogenesis, cell migration, cellular determination and differentiation, Neuronal growth cone and axon growth, Cell death in the nervous system, synapse formation,refinement of synaptic connections,astrocyte development and functions,oligodendrocyte development and functions, microglia development and functions.

Kavita Babu

Pre-requistes : None

References : None

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; Bacteria.

Dipshikha Chakravortty , Amit Singh , Samay Ravindra Pande

Pre-requistes : None

References : "Stanier, R.V.,Adelberg E.A and Ingraham J.L., GENERAL MICROBIOLOGY, Macmillan Press, Fourth edition Westriech, G.A. and Lechmann M.D., MICROBIOLOGY,Macmillan Press, Fifth Edition Atlas R.M.,MICROBIOLOGY: FUNDAMENTALS AND APPLICATIONS, Macmillan Press Second Edition Goldsby, R. A.,Kindt T. J.,Osborne B. A., Kuby J.,IMMUNOLOGY, W. H. Freeman &

MC 206 (AUG) 2 : 0

RNA Biology

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

Saibal Chatterjee , Purusharth Rajyaguru , Shovamayee Maharana

Pre-requistes : David G. Russell and Siamon Gordon,Phagocyte-Pathogen Interactions: Macrophages and the Host Response to Infection,ASM Press,2009.Knipe,D.M.

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

MC 207 (AUG) 3 : 0

Molecular Biology

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

Umesh Varshney , Shovamayee Maharana

Pre-requistes : None

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

MC 208 (AUG) 2 : 0

Principles of Genetic Engineering

Subba Rao Gangi Setty , Shashank Thripathi

Pre-requistes : None

References : None

MC 212 (AUG) 2 : 0

Advances in Cell Biology

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

Subba Rao Gangi Setty , Sachin Kotak

Pre-requistes : None

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

MC 205 (AUG) 2 : 0

Pathogen - Host interactions and immune evasion mechanisms

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

Balaji Kithiganahalli , Dipshikha Chakravortty

Pre-requistes : None

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

Molecular Biophysics Unit

MB 201 (AUG) 2 : 0

Introduction to Biophysical Chemistry

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

Raghavan Varadarajan

Pre-requistes : None

References : None

MB 204 (AUG) 3 : 0

Molecular Spectroscopy and its Biological Applications

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

Siddhartha P Sarma , Ashok Sekhar

Pre-requistes : None

References : None

MB 205 (AUG) 2 : 0

Introduction to X-ray Crystallography

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

Aravind Penmatsa

Pre-requistes : None

References : None

MB 214 (AUG) 3 : 0

Neuronal Physiology and Plasticity

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

Rishikesh Narayanan

Pre-requistes : None

References : None

RD 201 (AUG) 2 : 0

Genetics

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

Srimonta Gayen

Pre-requistes : None

References : 1. Concepts of Genetics by Klug, Cummings, Spencer, Palladino and Killian. 12th edition. 2. Epigenetics by David Allis, Marie-Laure Caparros, Thomas Jenuwein and Danny Reinberg, 2nd edition

RD 204 (AUG) 2 : 0

Principles of Signal Transduction in Biological Systems

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

Deepak Kumar Saini , Ramray Bhat

Pre-requistes : None

References : None

Division of Chemical Sciences

Preface

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

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

CD	Integrated Ph D
IP	Inorganic and Physical Chemistry
MR	Materials Research Centre
OC	Organic Chemistry
SS	Solid State and Structural Chemistry

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

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

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

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

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

Prof. G. Mugesh

Dean

Division of Chemical Sciences

Chemical Science

Integrated Phd in Chemical Science

CourseCode	CourseName	Credits
CD 204	Chemistry of Materials	3:0
CD 211	Physical Chemistry I Quantum Chemistry and Group Theory	3:0
CD 212	Inorganic Chemistry Main group and coordination chemistry	3:0
CD 213	Organic Chemistry Structure and Reactivity	3:0
CD 214	Basic Mathematics	3:0
CD 215	Organic & Inorganic Chemistry Laboratory	0:4
CD 402	Molecular Spectroscopy, Dynamics and Photochemistry	3:0
CD 221	Physical Chemistry II: Statistical Mechanics	3:0
CD 222	Material Chemistry	3:0
CD 223	Organic synthesis	3:0
CD 224	Computers in Chemistry	2:0
CD 225	Physical and Analytical Chemistry Laboratory	0:4
CD 241	Research Project	0:14
CD 301	Advanced NMR Spectroscopy	3:0

CD 213 (AUG) 3 : 0

Organic Chemistry – Structure and Reactivity

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

Uday Maitra,Mrinmoy De

Pre-requisites : None

References :

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

CD 204 (AUG) 3 : 0

Chemistry of Materials

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

Natarajan S

Pre-requisites : None

References : None

CD 211 (AUG) 3 : 0

Physical Chemistry – I Quantum Chemistry and Group Theory

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

Upendra Harbola

Pre-requisites : None

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

CD 214 (AUG) 3 : 0

Basic Mathematics

Differentiation and integration: different methods of evaluating integrals,multi-dimensional integrals, numerical integration. Vectors: gradient,divergence, dash and curl and their physical significance. Matrices: eigen values and eigen vectors.Complex variables: Cauchy- Reimann conditions,Cauchy's theorem,Cauchy's integral formula. Differential equations:differential equations of quantum chemistry and chemical kinetics,numericalsolutions of differential equations. The Dirac delta function, the gamma and error function. Function spaces, orthonormal functions, Fourier series,Fourier and Laplace transforms, fast Fourier transforms.

Balaram Sahoo

Pre-requisites : None

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

CD 215 (AUG) 0 : 4

Organic & Inorganic Chemistry Laboratory

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

Abhishake Mondal

Pre-requisites : None

References : None

CD 402 (AUG) 3 : 0

Molecular Spectroscopy, Dynamics and Photochemistry

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

Sai G Ramesh

Pre-requisites : None

References : None

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

Pre-requisites : None

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

Inorganic and Physical Chemistry

IP 203 (AUG) 3 : 0

Group Theory and Molecular Spectroscopy

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

Arunan E

Pre-requistes : None

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

IP 214 (AUG) 2 : 1

Crystallography for Chemists

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

Nethaji M

Pre-requistes : None

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

IP 311 (AUG) 3 : 0

Bio and Medicinal Inorganic Chemistry

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

Mugesh G

Pre-requistes : None

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

IP 312 (AUG) 3 : 0

Advanced Organometallic Chemistry

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

Balaji R Jagirdar , Thilagar P

Pre-requistes : None

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

MR 309 (AUG) 3 : 0

Introduction to Supramolecular Chemistry

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

Subinoy Rana

Pre-requistes : None

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

Organic Chemistry

OC 203 (AUG) 3 : 0

Organic Chemistry I

Uday Maitra

Pre-requistes : None

References : None

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

Pre-requistes : None

References : None

OC 231 (AUG) 3 : 0

Chemistry of Proteins and Peptides

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

Erode N Prabhakaran

Pre-requistes : None

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

OC 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 organometallinc reagents to imines, Asymmetric acetate/ propionate aldol reaction. Asymmetric allylation 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

Pre-requistes : None

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

OC 302 (AUG) 3 : 0

Asymmetric Catalysis: From Fundamentals to Frontiers

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

Santanu Mukherjee

Pre-requistes : None

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

OC 303 (AUG) 3 : 0

Carbohydrate Chemistry

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

Jayaraman N

Pre-requistes : None

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.

Solid State and Structural Chemistry

SS 201 (AUG) 3 : 0

Thermodynamics and Statistical Mechanics

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

Govardhan P Reddy

Pre-requistes : None

References : None

SS 202 (AUG) 3 : 0

Introductory Quantum Chemistry

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

Vivek Tiwari

Pre-requistes : None

References : None

SS 205 (AUG) 3 : 0

Symmetry and Structure in the Solid State

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

Guru Row T N

Pre-requistes : None

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

SS 209 (AUG) 3 : 0

Electrochemical Systems

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

Naga Phani B Aetukuri

Pre-requistes : None

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

SS 304 (AUG) 3 : 0

Solar Energy: Advanced Materials and Devices

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

Satish Amrutrao Patil

Pre-requistes : None

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

Division of Physical and Math. Sciences

Preface

The Division of Physical and Mathematical Sciences comprises the Department of Mathematics, Department of Instrumentation and Applied Physics, Department of Physics, Centre for Cryogenic Technology and Centre for High Energy Physics (formerly Theoretical Studies). The Joint Astronomy and Astrophysics Programme also comes under its purview.

The courses offered in the Division have been grouped into six broad areas. These areas have been identified by code letters as follows:

IN	Instrumentation and Applied Physics
MA	Mathematics
PH	Physics
HE	High Energy Physics
AA	Astronomy and Astrophysics
QT	Quantum Technology

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

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:

First semester		Second semester	
Quantum Field Theory I	3:0	The Standard Model of Particle Physics	3:0
Elective E1 (Two)	6:0	Elective E2 (None to Two)	0/3:0/6:0
	9		3/9

Third semester	
Elective E3 (None or One)	0/3:0
	0/3

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 haveto choose the electives in consultation with their supervisors.The supervisor may ask the students to take more electives thanthe list above, even after the Comprehensive Exam, as per his/herneeds 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 391 (AUG) 3 : 0

Quantum Mechanics III

Path integrals in quantum mechanics. Action and evolution kernels. Free particle and harmonic oscillator solutions. Perturbation theory, transition elements. Fermions and Grassmann integrals. Euclidean time formulation,statistical mechanics at finite temperature. Relativistic quantum mechanics,Klein-Gordon and Dirac equations. Antiparticles and hole theory. Klein paradox. Nonrelativistic reduction. Coulomb problem solution. Symmetries P, C and T,spin-statistics theorem. Lorentz and Poincare groups. Wigner classification of single particle states. Weyl and Majorana fermions. Modern topics such as graphene, Kubo formulae.

Sudhir Kumar Vempati

Pre-requistes : None

References : None

HE 395 (AUG) 3 : 0

Quantum Field Theory - I

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

Aninda Sinha

Pre-requistes : None

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

HE 394 (AUG) 3 : 0

Cosmology for Theorists

FLRW metric, redshift and cosmography, measuring distances, concordance LCDM model - dark matter/ energy, thermal history, nucleosynthesis, inflation, perturbation theory, evolution of perturbations and structure, CMB anisotropies, tension(s) between early and late universe.

Chethan Krishnan

Pre-requistes : Exposure to general relativity at the level of Einstein's equations and Schwarzschild solution, and exposure to QFT at the level of scalar field quantization will be assumed. But there are no hard pre-requisites.

References : Mukhanov - "Physical Foundations of Cosmology", Weinberg - "Cosmology"

Instrumentation and Applied Physics

M Tech in Instrumentation Systems
Duration: 2 Years
Credits: 64 credits

Credits

Type	Credits
Core	23
Elective	21
Project	20

Core (23 Credits)
18 credits from the pool below + 3 credit Mathematics course approved by the department

- IN 221 3:0 Sensors and Transducers
- IN 227 3:0 Control System Design
- IN 229 3:0 Advanced Instrumentation and Electronics
- IN 224 3:0 Nanoscience and Device Fabrication
- IN 244 2:1 Optical Metrology
- IN 222 2:1 Sensors and Transducers Lab
- IN 267 3:0 Fluorescence Microscopy and Imaging
- IN 270 3:0 Digital Signal Processing
- IN 302 3:0 Classical and Quantum Optics
- IN 214 3:0 Semiconductor Devices and Circuits
- IN 252 3:0 Optical Materials and Devices: From Fundamental Concepts to Recent Developments

Mandatory Seminar Courses in 3rd semester (2 credits)

Dissertation project:

- IN 299 MTech Dissertation Project (0:1 in 2nd semester ; 0:6 in 3rd semester; 0:13 in 4th semester) 0:20

List of Elective Courses offered by the Department of IAP (Students are allowed to choose any relevant courses from other departments as electives)

- IN 201 3:0 Analytical Instrumentation
- IN 202 3:0 Fundamentals of Metamaterials
- IN 203 3:0 Micro to Quantum supercapacitors
- IN 210 3:0 Wave Propagation in Periodic Media
- IN 212 3:0 Advanced Micro and nanosystems
- IN 223 3:0 Advanced Signal Processing
- IN 232 3:0 Concepts in Solid State Physics
- IN 234 3:0 Biomedical Optics and Spectroscopy
- IN 266 3:0 Introduction to Quantum Measurement and Control
- IN 271 3:0 Cryogenic Instrumentation and Applications

IN 201 (AUG) 3 : 0

Analytical Instrumentation

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

Asokan S

Pre-requistes : None

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

IN 221 (AUG) 3 : 0

Sensors and Transducers

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

Jayanth G R , Sanjiv Sambandan , Sai Siva Gorthi , Manish Arora , Baladitya Suri

Pre-requistes : None

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

IN 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

Pre-requistes : None

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

IN 270 (AUG) 3 : 0

Digital Signal Processing

Fourier analysis, Fourier Integral, Discrete Fourier transform multiplications of two signals, Z transform, convolution, correlation Digital filtering, Discrete transformation modulation, FIR, IIR filters, Analog I/O interphase for real time DSP system, application of TMS320 C6713DSK to evaluate convolution, IIR and FIR filter.

Jaya Prakash

Pre-requistes : None

References : Ervin Kreszic - Advanced engineering mathematics,Robert F Coughlin., Frederick F driscoll,opreational amplifier and linear integrated circuits.,Emmanual c Ifeachar

IN 302 (AUG) 3 : 0

Classical and Quantum Optics

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

Partha Pratim Mondal

Pre-requistes : None

References : None

IN 203 (AUG) 3 : 0

Micro to Quantum Supercapacitor Devices

Fundamentals of supercapacitor, Supercapacitor Fabrication, State-of-art supercapacitor design, Supercapacitor materials, Macro supercapacitor, Planar micro supercapacitor, Self-powered supercapacitor, Design of planar supercapacitor electrodes, Differences in macro-supercapacitor and planar supercapacitors, Mechanism of electrochemical interactions, Energy density and power density, Fundamentals of electromagnetic interaction in device design, Optically active devices and circuit design, Instrumentation of supercapacitor, Flexible electronics of supercapacitor, Ultra small planar devices, Device design parameters, Quantum Supercapacitors, Current technological advancements and future roadmap, Future Applications

Abha Misra

Pre-requistes : NA

References : 1- Electrochemical Supercapacitors, Author: B E Conway. 2- Semiconductor Devices and Circuits (Oxford Higher Education), by Aloke Dutta 3- Physics of Optoelectronics, by Michael A. Parker

Mathematics

Courses Offered in AUG 2021 semester: Mathematics

Course Number	Credits	Course Name	Nature	Instructor
MA 200	3:1	Multivariable Calculus	Core	Subhojoy Gupta
MA 212	3:0	Algebra I	Core	Mahesh Kakde
MA 219	3:1	Linear Algebra	Core	Apoorva Khare
MA 221	3:0	Analysis I: Real Anaysis	Core	Purvi Gupta
MA 231	3:1	Topology	Core	Siddhartha Gadgil
MA 261	3:0	Probability Models	Core	Sanchayan Sen
MA 223	3:0	Functional Analysis	Core	Tirthankar Bhattacharyya
MA 232	3:0	Introduction to Algebraic Topology	Core	Basudeb Datta
MA 242	3:0	Partial Differential Equations	Core	Swarnendu Sil
MA 220	3:0	Representation Theory of Finite Groups	Elective	Shaunak Deo
MA 304	3:0	Topics in Harmonic Analysis	Elective	S. Thangavelu
MA 312	3:0	Commutative Algebra	Elective	Abhishek Banerjee
MA 315	3:0	Lie algebras and their representations	Elective	R. Venkatesh
MA 323	3:0	Operator Theory	Elective	Srijan Sarkar
MA 326	3:0	Fourier Analysis	Elective	Manjunath Krishnapur
MA 328	3:0	Introduction to Several Complex Variables	Elective	E. K. Narayanan
MA 333	3:0	Riemannian Geometry	Elective	Ved Datar
MA 350	3:0	Topics in Analytic Number Theory	Elective	Soumya Das
MA 353	3:0	Elliptic Curves	Elective	Radhika Ganapathy
MA 361	3:0	Probability Theory	Elective	Srikanth Iyer

Courses Offered in JAN 2022 semester: Mathematics

Course Number	Credits	Course Name	Nature	Instructor
MA 213	3:1	Algebra II	Core	Shaunak Deo
MA 222	3:1	Measure & Integration	Core	Manjunath Krishnapur
MA 224	3:1	Complex Analysis	Core	E. K. Narayanan
MA 235	3:0	Introduction to Differentiable Manifolds	Core	Ved Datar
MA 241	3:1	Ordinary Differential Equations	Core	Harish Sheshadri
MA 263	3:0	Stochastic Finance	Elective	Srikanth Iyer
MA 308	3:0	Algebraic Geometry	Elective	Abhishek Banerjee
MA 313	3:0	Algebraic Number Theory	Elective	Soumya Das
MA 322	3:0	Topics in Harmonic Analysis II	Elective	S. Thangavelu
MA 324	3:0	Topics in Complex Analysis	Elective	Purvi Gupta
MA 332	3:0	Algebraic Topology	Elective	Siddhartha Gadgil
MA 347	3:0	Advanced PDE and FEM	Elective	Thirupathi Gudi
MA 355	3:0	Topics in Geometric Topology: Geometric structures	Elective	Subhojoy Gupta
MA 374	3:0	Introduction to Calculus of Variations	Elective	Swarnendu Sil
MA 386	3:0	Coxeter Groups	Elective	R. Venkatesh
MA 390	3:0	Topics: Percolation	Elective	Sanchayan Sen

Mathematics

MA 219 (AUG) 3 : 1

Linear Algebra

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

Apoorva Khare

Pre-requistes : None

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

MA 220 (AUG) 3 : 0

Representation theory of Finite groups

Representation of finite groups, irreducible representations, complete reducibility, Schur's lemma, characters, orthogonality, class functions, regular representations and induced representation, the group algebra. Linear groups: Representation of the group SU2 Books Aritin, M., Algebra, Prentice Hall of India, 1994. Fulton W., and Harris, J., Representation Theory,Spinger-Verlag, 1991. Serre, J.P., Linear Representations of Finite Groups,Springer-Verlag, 1977.

Shaunak Vilas Deo

Pre-requistes : None

References : Etingof Pavel, Golberg Oleg, Hensel Sebastian, Liu Tiankai, Schwendner Alex,Vaintrob Dmitry, Yudovina Elena,, Introduction to representation theory. With historical interludes by Slava Gerovitch, Student Mathematical Library 59. American Mathematical Society. 2011.~J. P. Serre. Graduate Texts in Mathematics. Vol. 42. Springer-Verlag. New York-Heidelberg, 1977.

MA 223 (AUG) 3 : 0

Functional Analysis

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

Tirthankar Bhattacharyya

Pre-requistes : None

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

MA 231 (AUG) 3 : 1

Topology

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

Siddhartha Gadgil

Pre-requistes : None

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

MA 232 (AUG) 3 : 0

Introduction to Algebraic Topology

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

Basudeb Datta

Pre-requistes : None

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

MA 242 (AUG) 3 : 0

Partial Differential Equations

Swarnendu Sil

Pre-requistes : None

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

MA 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.

Sanchayan Sen

Pre-requistes : None

References : Ross,S.M.,Introduction to Probability Models,Academic Press 1993., Taylor~Taylor, H.M., and Karlin, S., An Introduction to Stochastic Modelling, Academic Press, 1994.

MA 304 (AUG) 3 : 0

Topics in Harmonic Analysis

Syllabus: Fractional powers of Laplacian $ \Delta $ on $ \R^n $ and sublaplacian $ \mathcal{L} $ on Heisenberg groups. Complementary series representations. Branching problem. Poisson transforms. 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

Pre-requistes : None

References : L. A. Caffarelli and L. Silvestre, {An extension problem related to the fractional Laplacian}, \textit{Comm. Partial Differential Equations} \textbf{32} (2007), 1245--1260. S-Y. A. Chang and M.d.M. Gonz\'alez, {Fractional Laplacian in conformal geometry}, \textit{Adv. Math.} \textbf{226}(2011), no. 2, 1410--1432. R. L. Frank, M.d.M. Gonz\'alez, D. D. Monticelli and J. Tan, An extension problem for the CR

MA 312 (AUG) 3 : 0

Commutative Algebra

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

Abhishek Banerjee

Pre-requistes : None

References : None

MA 315 (AUG) 3 : 0

Lie Algebra and Their Representation

Finite dimensional Lie algebras, Ideals, Homomorphisms, Solvable and Nilpotent Lie algebras, Semisimple Lie algebras, Jordan decomposition, Kiling form, root space decomposition, root systems, classification of complex semisimple Lie algebras Representations Complete reducibility, weight spaces, Weyl character formula, Kostant, steinberg and Freudenthal formulas

Venkatesh R

Pre-requistes : None

References : J E Humphreys Introduction to Lie algebras and Representation theory Springer-Verlag, 1972~J P Serre Complex Semisimple Lie Algebras, Springer, 2001~Fulton.W., and Harris J. Representation theory, Springer- Verlag. 1991

MA 323 (AUG) 3 : 0

Operator Theory

Bounded linear operators: Spectral theory of compact, self adjoint, and normal operators. Sturm-Liouville problems, Green's function, Fredholm integral operators. Unbound linear operators on Hilbert spaces: Symmetric and self adjoint operators, Spectral theory, Banach algebras, Gelfand representation theorem, C*-algebras, Gelfand-Naimark-Segal construction.

Thirupathi Gudi

Pre-requistes : None

References : Conway, J. B., A course in Functional Analysis, Springer-Verlag, 1990 ~Rudin, W. , Functional Analysis, Tata Mcgraw-Hill, 1974~Berberian, S. K., Lectures in Functional Analysis, Frederic Ungar, 1955

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.

Manjunath Krishnapur

Pre-requistes : None

References : None

MA 328 (AUG) 3 : 0

Introduction to Several Complex Variables

Preliminaries: Holomorphic functions in Cn : definition, the generalized Cauchy integral formula, holomorphic functions: power series development (s),circular and Reinhardt domains, analytic continuation : basic theory and comparisons with the one- variable theory. Convexity theory: Analytic continuation: the role of convexity, holomorphic convexity, plurisub-harmonic functions, the Levi problem and the role of the d-bar equation. The d-bar equation: Review of distribution theory, Hormander's solution and estimates for the d-bar operator.

Narayanan E K

Pre-requistes : None

References : Lars Hormander, An Introduction to Complex Analysis in Several Variables, 3rd edition, North-Holland Mathematical Library, North- Holland, 1989.~Function Theory of Several Complex Variables, 2nd edition, Wadsworth & Brooks/Cole,1992.~Raghavan Narasimhan, Several Complex Variables, Chicago Lectures in Mathematics Series, The University of Chicago Press, 1971.

MA 333 (AUG) 3 : 0

Riemannian Geometry

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

Ved V Datar

Pre-requistes : None

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

MA 350 (AUG) 3 : 0

Analytic Number Theory

Soumya Das

Pre-requistes : None

References : None

MA 353 (AUG) 3 : 0

Elliptic Curves

Elliptic curves are smooth projective curves of genus 1 with a marked point.cOver a field of characteristic zero they are given by an equation of the form y^2=x^3+ax+b. They are at the boundary of our (conjectural) understanding of rational points on varieties and are subject of many famous conjectures as well as celebrated results. They play an important role in number theory. The course will begin with an introduction to algebraic curves. We will then study elliptic curves over complex number, over finite fields, over local fields of characteristic zero and finally over number fields. Our goal will be to prove the Mordell-Weil theorem.

Radhika Ganapathy

Pre-requistes : None

References : Joseph Silverman, The arithmetic of elliptic curves, Springer GTM 106, 2009~Joseph Silverman and John Tate, Rational points on elliptic curves, Springer UTM, 1992~J.W.S. Cassels, Lectures on elliptic curves, Cambridge University Press, 2012

MA 361 (AUG) 3 : 0

Probability theory

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

Srikanth Krishnan Iyer

Pre-requistes : None

References : Durrett, R., Probability: Theory and Examples (4th Ed.), Cambridge University Press, 2010.~Billingsley, P., Probability and Measure (3rd Ed.), Wiley India,2008.~Walsh, J., Knowing the Odds: An Introduction to Probability, AMS, 2012.~Kallenberg, O., Foundations of Modern Probability (2nd Ed.), Springer-Verlag,2002.

MA 200 (AUG) 3 : 1

Multivariable Calculus

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

Subhojoy Gupta

Pre-requistes : None

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

MA 212 (AUG) 3 : 0

Algebra I

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

Mahesh Ramesh Kakde

Pre-requistes : None

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

MA 221 (AUG) 3 : 0

Analysis I

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

Purvi Gupta

Pre-requistes : None

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

MA 223 (AUG) 3 : 0

Functional Analysis

Tirthankar Bhattacharyya

Pre-requistes : None

References : None

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.

Departmental I-PhD Core Courses

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

Project:

Sl. No	Course No.	Credits	Term
01	**PH 250A**	**0:6**	**January**
02	**PH 250B**	**0:6**	**May-June**

JAP Core Courses :

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

Elective Courses:

#	Course No.	Credits	Course title	Nature	Term
1	PH 320	3:0	Condensed Matter Physics II	Elective	August
2	PH 322	3:0	Molecular Simulation	Elective	Jan
3	PH 325	3:0	Advanced Statistical Physics	Elective	August
4	PH 333	3:0	Physics of Disordered Systems	Elective	Jan
5	PH 335	3:0	Modern topics in condensed matter	Elective	Jan
6	PH 340	4:0	Quantum Statistical Field Theory	Elective	Jan
7	PH 350	3:0	Physics of Soft Condensed Matter	Elective	Jan
8	PH 351	3:0	Crystal Growth, Thin Films and Characterization	Elective	August
9	PH 352	3:0	Semiconductor Physics and Technology	Elective	Jan
10	PH 353	3:0	Principles of Magnetism in Solids	Elective	Aug
11	PH 354	3:0	Computational Physics	Elective	Jan
12	PH 359	3:0	Physics at the Nanoscale	Elective	Jan

13	PH 360	3:0	Biological Physics	Elective	Aug
14	PH 364	3:0	Topological Phases of Matter (Theory and experiment)	Elective	Jan
16	PH 366	3:0	Physics of Advanced Optical Materials	Elective	Jan

HE 215 (AUG) 3 : 0

Nuclear and Particle Physics

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

Jyothsna Rani Komaragiri

Pre-requistes : None

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

PH 201 (AUG) 3 : 0

Classical Mechanics

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

Animesh Kuley

Pre-requistes : None

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

PH 203 (AUG) 3 : 0

Quantum Mechanics-I

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

Tanmoy Das

Pre-requistes : None

References : None

PH 205 (AUG) 3 : 0

Math Methods of Physics

Linear vector spaces, linear operators and matrices, systems of linear equations. Eigen values and eigen vectors, classical orthogonal polynomials. Linear ordinary differential equations, exact and series methods of solution,special functions. Linear partial differential equations of physics, separation of variables method of solution. Complex variable theory; analytic functions. Taylor and Laurent expansions, classification of singularities, analytic continuation, contour integration, dispersion relations. Fourier and Laplace transforms

Sriram Ramaswamy

Pre-requistes : None

References : None

PH 213 (AUG) 0 : 4

Advanced Experiments in Condensed Matter Physics

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

Anil Kumar P S

Pre-requistes : None

References : None

PH 215 (AUG) 3 : 0

Nuclear and Particle Physics

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

Jyothsna Rani Komaragiri

Pre-requistes : None

References : None

PH 217 (AUG) 3 : 0

Fundamentals of Astrophysics

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

Banibrata Mukhopadhyay

Pre-requistes : None

References : None

PH 322 (AUG) 3 : 0

Molecular Simulation

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

Prabal Kumar Maiti , Anand Srivastava

Pre-requistes : None

References : None

PH 325 (AUG) 3 : 0

Advanced Statistical Physics

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

Sumilan Banerjee

Pre-requistes : None

References : None

PH 351 (AUG) 3 : 0

Crystal Growth, Thin films and Characterization

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

Akshay Singh

Pre-requistes : None

References : None

PH 362 (AUG) 2 : 0

Radiative Processess in Astrophysics

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

Nirupam Roy

Pre-requistes : None

References : None

PH 363 (AUG) 2 : 0

Introduction to Fluid Mechanics and Plasma Physics

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

Arnab Rai Choudhuri

Pre-requistes : None

References : None

PH 320 (AUG) 3 : 0

Condensed Matter Physics II

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

Subroto Mukerjee

Pre-requistes : None

References : None

QT 207 (AUG) 3 : 0

Introduction to Quantum Computation

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

Apoorva Patel

Pre-requistes : None

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

QT 201 (AUG) 1 : 0

Survey of Quantum Technologies

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

Apoorva Patel , Baladitya Suri

Pre-requistes : None

References : Online talks.

QT 209 (AUG) 3 : 0

Introduction to Quantum Communications and Cryptography

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

Apoorva Patel , Varun Raghunathan , Asha Bhardwaj , Baladitya Suri

Pre-requistes : None

References : Nielsen M.A. and Chuang I.L., Quantum Computation and Quantum Information, Cambridge University Press, 2000. Preskill J., Lecture Notes for the Course on Quantum Computation, http://www.theory.caltech.edu/people/preskill/ph229

QT 211 (AUG) 1 : 2

Basic Quantum Technology Laboratory

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

Vibhor Singh

Pre-requistes : None

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

Division of Electrical, Electronics and Computer Sciences (EECS)

Preface

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

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

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

M Tech in Electrical Engineering (EE)

M Tech in Communication and Networks (ECE)

M Tech in Computer Science and Engineering (CSA)

M Tech in Electronics Systems Engineering (ESE)

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

M Tech in Signal Processing (EE and ECE)

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

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

Prof. Rajesh Sundaresan

Dean

Division of EECS

E0 238 (AUG) 3 : 1

Intelligent Agents

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

Pre-requistes : None

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

E0 222 (AUG) 3 : 1

Automata Theory and Computability

Finite-state automata, including the Myhill-Nerode theorem,ultimate periodicity, and Buchi's logical characterization. Pushdown automata and Context-free languages, including deterministic PDA's,Parikh's theorem, and the Chomsky-Shutzenberger theorem. Turing machines and undecidability,including Rice's theorem and Godel's incompleteness theorem.

Deepak D'Souza

Pre-requistes : None

References : 1. Hopcroft J.E. and Ullman J.D.: Introduction to Automata, Languages and Computation. Addison Wesley, 1979. Dexter Kozen: Automata and Computability. 2. Springer 1999. Wolfgang Thomas: Automata on infinite objects, in Handbook of Theoretical Computer Science, Volume B,Elsevier, 1990.

E0 224 (AUG) 3 : 1

Computational Complexity Theory

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

Chandan Saha

Pre-requistes : None

References : None

E0 225 (AUG) 3 : 1

Design and Analysis of Algorithms

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

Sathish Govindarajan

Pre-requistes : None

References : None

E0 226 (AUG) 3 : 1

Linear Algebra and Probability

Linear Algebra: System of Linear Equations, Vector Spaces, Linear Transformations, Matrices, Polynomials, Determinants, Elementary Canonical Forms, Inner Product Spaces, Orthogonality. Probability: Probability Spaces,Random Variables, Expectation and Moment generating functions, Inequalities,Some Special Distributions. Limits of sequence of random variables,Introduction to Statistics, Hypothesis testing.

Gugan Chandrashekhar Thoppe

Pre-requistes : None

References : Gilbert Strang,Linear Algebra and its Applications,Thomson-Brooks/ Cole,4th edition,2006.~Hoffman and Kunze

E0 227 (AUG) 3 : 1

Program Analysis and Verification

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

Deepak D'Souza , Raghavan K V

Pre-requistes : None

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

E0 230 (AUG) 3 : 1

Computational Methods of Optimization

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

Chiranjib Bhattacharyya

Pre-requistes : None

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

E0 235 (AUG) 3 : 1

Cryptography

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

Arpita Patra

Pre-requistes : None

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

E0 243 (AUG) 3 : 1

Computer architecture

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

Govindarajan R , Arkaprava Basu

Pre-requistes : None

References : None

E0 254 (AUG) 3 : 1

Network and Distributed Systems Security

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

Ramesh Chandra Hansdah

Pre-requistes : None

References : William Stallings: Cryptography and Network Security: Principles and Practices, Fourth Edition, Prentice Hall,2006. Neil Daswani, Christoph Kern and Anita Kesavan: Foundations of Security.

E0 267 (AUG) 3 : 1

Soft Computing

To introduce the student to the soft computing paradigm as compared to hard computing. To make them learn the techniques of soft computing like neural networks, fuzzy and rough systems, evolutionary algorithms etc. which can be applied to the task of classification,clustering, and other applications. Definition of soft computing, Soft computing vs. Hard computing; Advantages of soft computing, tools and techniques; Neural Networks : Fundamentals,backpropogation,associative memory, self organizing feature maps,applications;Fuzzy and rough sets : Concepts and applications; Evolutionary algorithms, swarm intelligence, particle swarm optimization, ant colony optimization,applications;Hybrid systems : Integration of neural networks, fuzzy logic and genetic algorithms, integration of genetic algorithms and particle swarm optimization, Applications.

Susheela Devi V

Pre-requistes : None

References : References: Timothy J.Ross,"Fuzzy Logic with Engineering Applications", McGraw-Hill,1997 David E.Goldberg,Genetic Algorithms in Search, Opt.

E0 271 (AUG) 3 : 1

Graphics and Visualization

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

Vijay Natarajan

Pre-requistes : None

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

E0 327 (AUG) 3 : 1

Topics in Program Analysis

Finite-state automata, including the Myhill-Nerode theorem,ultimate periodicity, and Buchi's logical characterization. Pushdown automata and Context-free languages, including deterministic PDA's,Parikh's theorem, and the Chomsky-Shutzenberger theorem. Turing machines and undecidability,including Rice's theorem and Godel's incompleteness theorem.

Deepak D'Souza

Pre-requistes : None

References : 1. Hopcroft J.E. and Ullman J.D.: Introduction to Automata, Languages and Computation. Addison Wesley, 1979. Dexter Kozen: Automata and Computability. Springer 1999. Wolfgang Thomas: Automata on infinite objects, in Handbook of Theoretical Computer Science, Volume B, Elsevier, 1990.

E0 334 (AUG) 3 : 1

Deep Learning for Natural Language Processing

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

Shirish Krishnaji Shevade

Pre-requistes : None

References : Ian Goodfellow , Yoshua Bengio and Aaron Courville.Deep Learning. MIT Press, 2016 Recent Literature.

E0 361 (AUG) 3 : 1

Topics in Database Systems

Object-oriented Databases, Distributed and Parallel Databases,Multi- databases, Access Methods, Transaction Management, Query Processing,Deductive Databases, multimedia Databases, Real- Time Databases, Active Databases, Temporal Databases, Mobile Databases, Database Benchmarks,Database Security, Data Mining and Data Warehousing.

Jayant R Haritsa

Pre-requistes : None

References : None

E1 396 (AUG) 3 : 1

Topics in Stochastic Approximation Algorithms

Shalabh Bhatnagar

Pre-requistes : None

References : None

E0 206 (AUG) 3 : 1

Theorist's Toolkit

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

Anand Louis , Arindam Khan

Pre-requistes : None

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

E0 229 (AUG) 3 : 1

Foundations of Data Science

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

Siddharth Barman

Pre-requistes : None

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

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

Pre-requistes : None

References : Research papers

E0 388 (AUG) 2 : 2

Topics in AI for Social Good

AI for Social Good Process: Problem definition, domain knowledge acquisition, data collection and curation, algorithm and solution, proof of concept, deployment. AI for Social Good Toolkit : An overview of techniques and tools from data science,optimisation,machine learning, and game theory used in AI for Social Good applications. Key Requirements: Scalability,Explainability,Fairness, Ethics. Case Studies: Selected case studies from Agriculture, Digital Healthcare, Covid 19, Education, Sustainability, Wildlife Conservation, Transportation, Delivery of Justice, Climate Modeling, Matchings, Fair Division. Agriculture:Crop price prediction, crop recommendation, markets for social welfare maximisation, cooperative farming, precision agriculture, food processing, supply chain issues, incentive design, policy making . Pandemics: AI methods for diagnosis, lockdowns and relaxations, testing strategies, vaccinations, planning public health resources, incentive design

Narahari Y

Pre-requistes : The student must have credited at least two of the following courses: E0 270 (Machine Learning), E1 213 (Pattern Recognition and Neural Networks); E2 236 (Foundations of Machine Learning); E1 277 (Reinforcement Learning); E1 254 (Game Theory); E0 259 (Data Analytics); E0 265 (Convex Optimisation and Applications); E0 230 (Computational Methods of Optimisation); E0

References : Current Literature

E0 360 (AUG) 3 : 1

Hypergraphs and Set systems

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

Sunil Chandran L

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

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

E0 359 (AUG) 3 : 1

Topics in Computer Systems Security

This course will be an advanced course in computer systems security. The goal of the course will be to cover recent advances in the field, covering topics such as IoT/CPS security and privacy, cloud platform security and privacy, and the privacy and security of AI/ML systems. The goal of the course is to bring students up to speed with the research frontier in these topics. Syllabus: The syllabus of the course will be recent research articles on these topics drawn from leading venues such as the IEEE Symposium on Security and Privacy, USENIX Security, ACM Conference on Computer and Communications Security, the ACM Symposium on Operating Systems Principles/Operating Systems Design and Implementation, ACM Conference on Mobile Systems,Applications and Services, the ACM SIGCOMM Conference on Data Communication, and the Networked Systems Design and Implementation Symposium. Approximately 2-3 research papers will be covered each week.

Vinod Ganapathy

Pre-requistes : E0-256 is a pre-requisite. Students who have not taken E0-256 require the consent of the instructor to be able to register.

References : None

M.Tech Electronics & Communication Engineering

OVERALL STRUCTURE: The programme requires 36 credits of coursework and 28 credits of project work.

The coursework requirements in the program include three compulsory core courses and at least one course from each of the three broad groups of courses listed below.

Program Core (9 credits)	E2 202 (AUG) 3:0 Random Processes E2 211 (AUG) 3:0 Digital Communication [New] Ex xxx (JAN) 1:2 Communication Laboratory
Group A (Communication & Networks) (at least 3 credits)	E2 201 (AUG) 3:0 Information Theory E2 205 (AUG) 3:0 Error-Correcting Codes E2 221 (AUG) 3:0 Communication Networks E2 251 (AUG) 3:0 Communication Systems Design E2 203 (JAN) 3:0 Wireless Communication E2 204 (JAN) 3:0 Stochastic Processes and Queuing Theory E2 241 (JAN) 3:0 Wireless Networks E2 242 (JAN) 3:0 Multiuser Detection
Group B (Signal & Information Sciences) (at least 3 credits)	E1 245 (AUG) 3:0 Online Prediction and Learning E2 212 (AUG) 3:0 Matrix Theory E9 241 (AUG) 2:1 Digital Image Processing E9 211 (AUG) 3:0 Adaptive Signal Processing E1 244 (JAN) 3:0 Estimation and Detection Theory E2 236 (JAN) 3:1 Foundations of Machine Learning E9 203 (JAN) 3:0 Compressive Sensing and Sparse Signal Processing E9 231 (JAN) 3:0 MIMO Signal Processing E0 259 (AUG) 3:1 Data Analytics
Group C (High Frequency Circuits & Systems) (at least 3 credits)	E3-238 (AUG) 2:1 Analog VLSI Circuits E3-220 (AUG) 3:0 Foundations of Nanoelectronic Devices E7-221 (AUG) 3:0 Fiber optic communication E3 237 (JAN) 3:0 Integrated Circuits for Wireless Communication E7 211 (JAN) 2:1 Photonics Integrated Circuits E8-211(JAN) 3:0 Antenna Theory and Practice E8 242 (JAN) 2:1 Radio Frequency Integrated Circuits and Systems E8 262 (JAN) 3:0 CAD for high-speed Circuit
Electives: balance to meet a minimum of 36 course credit	
Project (28 credits)	

Departments of Electronic Systems Engineering and Electrical Communication Engineering

MTech Microelectronics and VLSI Design

Duration: 2 Years			**Total Credits: 64**
Core Courses: 18 credits, mandatory for all students.			
E0 284	2:1	Aug	Digital VLSI Circuits
E3 200	1:2	Jan	Microelectronics Lab
E3 220	3:0	Aug	Foundations of Nanoelectronics Devices
E3 231	2:1	Jan	Digital Systems Design with FPGAs
E3 238	2:1	Aug	Analog VLSI Circuits
E3 282	3:0	Jan	Basics of Semiconductor Devices and Technology
Electives: 18 credits (all at 200 level or higher). 1. Students can choose any course from the offered list across the institute. The following courses, listed in the Scheme of Instruction, are merely suggestions. **2.** Crediting two courses having similar syllabus/content is strictly discouraged			
E1 201	2:1	Jan	Hardware Acceleration and Optimization for Machine Learning
E3 225	3:0	Aug	Art of Compact Modelling
E3 237	3:0	Jan	Integrated Circuits for Wireless Communication
E3 245	2:1	Aug	Processor System Design
E3 271	1:2	Jan	Reliability of Nanoscale Circuits and Systems
E3 274	1:2	Jan	Design of Power Semiconductor Devices
E3 275	2:1	Jan	Physics and Design of Transistors
E3 280	3:0	Jan	Carrier Transport in Nanoelectronics Devices
E3 301	3:0	Jan	Special topics in Nanoelectronics
E7 211	2:1	Jan	Photonic Integrated Circuits
E7 214	3:0	Jan	Optoelectronic Devices
E8 202	2:1	Aug	Computational Electromagnetics
E8 242	2:1	Jan	RF IC and Systems
E8 262	3:0	Jan	CAD for High Speed Chip-Package-Systems
NE 203	3:0	Aug	Advanced Micro and Nano Fabrication Technology and Process
NE 205	3:0	Aug	Semiconductor Devices and Integrated Circuit Technology
NE 215	3:0	Aug	Applied Solid State Physics
NE 222	3:0	Aug	MEMS: Modeling, Design, and Implementation
NE 241	3:0	Aug	Material Synthesis: Quantum Dots to Bulk Crystals
NE 202	0:1	Jan	Device Fabrication Lab Module (Micro and Nano Fabrication)

NE 201	2:1	Jan	Micro and Nano Characterization Methods
NE 314	3:0	Jan	Semiconductor Opto-electronics and Photovoltaics
NE 221	2:1	Jan	Advanced MEMS Packaging Lab: Packaging Lab
IN 221	3:0	Aug	Sensors and Transducers
IN 229	3:0	Aug	Advanced Instrumentation Electronics
IN 212	3:0	Jan	Advanced Nano/Micro Systems
IN 214	3:0	Jan	Semiconductor Devices and Circuits
IN 224	3:0	Jan	Nanoscience and Device Fabrication
MT 209	3:0	Aug	Defects in Materials
MT 213	3:0	Jan	Electronic Properties of Materials
E3 257	2:1	Jan	Embedded System Design
E3 276	2:1	Jan	Process Tech & System Eng for Adv Microsensors and Devices
PH 203	3:0	Aug	Quantum Mechanics-I
PH 208	3:0	Jan	Condensed Matter Physics-I
PH 352	3:0	Jan	Semiconductor Physics
PH 359	3:0	Jan	Physics at Nanoscale
MR 303	3:0	Aug	Nanomaterials Synthesis and Devices
MR 307	3:0	Jan	Thin Film, Nano Materials and Devices: Science and Engineering
MR 308	2:1	Jan	Computational Modeling of Materials
Project: 28 Credits			
MV 299	0:28		Dissertation Project

E3 238 (AUG) 2 : 1

Analog VLSI Circuits

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

Arup Polley

Pre-requistes : None

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

E0 259 (AUG) 3 : 1

Data Analytics

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

Rajesh Sundaresan

Pre-requistes : None

References : None

E1 245 (AUG) 3 : 0

Online Prediction and Learning

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

Aditya Gopalan

Pre-requistes : None

References : Prediction, Learning and Games. Nicolo Cesa-Bianchi and Gabor Lugosi,Cambridge University Press, 2006~Online Learning and Online Convex Optimization. Shai Shalev-Shwartz. Foundations and Trends in Machine Learning Vol. 4, No. 2 (2011) 107–194, DOI:10.1561/2200000018 ~Regret Analysis of Stochastic and Nonstochastic Multi-armed Bandit Problems.Sebastien Bubeck and Nicolo

E2 201 (AUG) 3 : 0

Information Theory

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

Chandra R Murthy

Pre-requistes : None

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

E2 202 (AUG) 3 : 0

Random Processes

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

Parimal Parag

Pre-requistes : None

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

E2 205 (AUG) 3 : 0

Error-Control Coding

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

Navin Kashyap

Pre-requistes : None

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

E2 211 (AUG) 3 : 0

Digital Communication

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

Sundar Rajan B

Pre-requistes : None

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

E2 212 (AUG) 3 : 0

Matrix Theory

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

Ramakrishnan A G

Pre-requistes : None

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

E2 221 (AUG) 3 : 0

Communication Networks

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

Rahul Singh

Pre-requistes : None

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

E2 251 (AUG) 3 : 0

Communications Systems Design

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

Chockalingam A

Pre-requistes : None

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

E2 302 (AUG) 3 : 0

Next Generation Wireless Systems: Design and Analysis

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

Neelesh B Mehta

Pre-requistes : None

References : None

E2 331 (AUG) 3 : 0

Advanced Topics in Coding Theory

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

Sundar Rajan B

Pre-requistes : None

References : None

E3 237 (AUG) 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

Pre-requistes : None

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

E7 211 (AUG) 2 : 1

Photonics Integrated Circuits

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

Srinivas Talabattula , Varun Raghunathan

Pre-requistes : None

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

E8 202 (AUG) 2 : 1

Computational Electromagnetics

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

Dipanjan Gope

Pre-requistes : None

References : A. Taflove and SC Hagness Computational Electrodynamics: The Finite Difference Time Domain Method, 3rd Ed., Artech House.~Andrew F. Peterson, Scott L. Ray,Raj Mittra: Computational Methods for Electromagnetics, 1st Ed., IEEE Press Series on Electromagnetic Wave Theory.~Walton C. Gibson: The Method of Moments in Electromagnetics, 1st Ed., Chapman and Hall.~Roger F.

E9 211 (AUG) 3 : 0

Adaptive Signal Processing

Review of estimation theory. Wiener Solution. Kalman filter and its application to estimation, filtering and prediction. Iterative solution;of method of steepest descent and its convergence criteria, least mean square gradient algorithm (LMS), criteria for convergence and LMS versions:normalized LMS, leaky, sign, variable stepsize, transform domain LMS algorithm using DFT and DCT. Block LMS (BLMS) algorithm:frequency domain BLMS (FBLMS).Recursive least square (RLS) method, fast transversal, fast lattice RLS and affine projection algorithms.Applications of adaptive filtering: spectral estimation, system identification, noise cancelling acoustic and line echo cancellation,channel equalization.

Hari K V S

Pre-requistes : None

References : Ali H Sayed, Adaptive Filters, John Wiley/IEEE, 2008

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

Pre-requistes : None

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.

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

Pre-requistes : None

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

E1 260 (AUG) 3 : 1

Optimization for Machine Learning and Data Science

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

Sundeep Prabhakar Chepuri

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

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

E8 304 (AUG) 3 : 0

Electromagnetic Metamaterials: Concepts and Applications

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

Debdeep Sarkar

Pre-requistes : Preliminary knowledge about circuit design concepts along with electromagnetic theory, transmission lines, waveguides, and radiators (GATE ECE Level) would be useful. Also it will be good to have some antenna background.

References : 1. D. K. Cheng, Field and Wave Electromagnetics, Pearson Education Asia Ltd, Second Edition, 2006. 2. S. A. Ramakrishna and T.M.Grzegorczyk, Physics and Applications of Negative Refractive Index Materials, CRC Press, Taylor & Francis Group and SPIE Press,2009. 3. G. V. Eleftheriades and K. G. Balmain, Negative Refraction Metamaterials: Fundamental Principles and Applications

E1 251 (AUG) 3 : 0

Linear and Nonlinear Optimization

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

Muthuvel Arigovindan

Pre-requistes : None

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

E9 201 (AUG) 3 : 0

Digital Signal Processing

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

Soma Biswas , Prasanta Kumar Ghosh

Pre-requistes : None

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

E0 247 (AUG) 3 : 1

Sensor Networks

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

Rathna G N

Pre-requistes : None

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

E0 299 (AUG) 3 : 1

Computational Linear Algebra

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

Kunal Narayan Chaudhury

Pre-requistes : None

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

E1 222 (AUG) 3 : 0

Stochastic Models and Applications

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

Subbayya Sastry P

Pre-requistes : None

References : References: Ross S M,Introduction to Probability Models,(6th Edition),academic Press and Hardcourt Asia,2000.

E1 241 (AUG) 3 : 0

Dynamics of Linear Systems

Background material on matrix algebra, differential equations. Representation of dynamic systems, equilibrium points and linearization. Natural and forced response of state equations, state space descriptions, canonical realizations. Observability and controllability, minimal realization. Linear state variable feedback,stabilization, modal controllability, Jordan form, functions of matrices, pole- placement, Lyapunov matrix equations. Asymptotic observers, compensator design, and separation principle. Preliminary quadratic regulator theory.

Vaibhav Katewa

Pre-requistes : None

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

E4 231 (AUG) 3 : 0

Power System Dynamics and Control

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

Gurunath Gurrala

Pre-requistes : None

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

E4 234 (AUG) 3 : 0

Advanced Power Systems Analysis

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

Sarasij Das

Pre-requistes : None

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

E5 206 (AUG) 3 : 0

HV Power Apparatus

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

Satish L , Rajanikanth B S , Udaya Kumar

Pre-requistes : None

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

E6 201 (AUG) 3 : 1

Power Electronics

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

Narayanan G , Vishnu Mahadeva Iyer

Pre-requistes : None

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

E6 221 (AUG) 3 : 0

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 modul

Vinod John

Pre-requistes : None

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

E6 221 (AUG) 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.

Narayanan G , Vinod John

Pre-requistes : None

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

E6 223 (AUG) 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

Pre-requistes : None

References : References: Mohan, Undeland and Robbins; Power Electronics; Converters, Applications and Design, John Wiley and Sons, 1989.,Erickson R W, Fundamentals of Power Electronics, Chapman and Hall, 1997.,Vithyathil J, Power Electronics:Principles and Applications; McGraw Hill, 1995. Current Literature.

E6 225 (AUG) 3 : 0

Advanced Power Electronics

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

Kaushik Basu

Pre-requistes : None

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

E8 201 (AUG) 3 : 0

Electromagnetism

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

Udaya Kumar

Pre-requistes : None

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

E9 245 (AUG) 3 : 1

Selected Topics in Computer Vision

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

Srinivasa Venu Madhav Govindu

Pre-requistes : None

References : None

E1 246 (AUG) 3 : 0

Topics in Networked and Distributed Control

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

Pavankumar Tallapragada

Pre-requistes : None

References : 1. Bemporad, Alberto, Maurice Heemels, and Mikael Johansson. Networked control systems. Vol. 406. London: Springer, 2010.~2. Yüksel, Serdar, and Tamer Basar.Stochastic networked control systems: Stabilization and optimization under information constraints. Springer Science & Business Media, 2013.~3. Mesbahi,Mehran, and Magnus Egerstedt. Graph theoretic methods in multiagent

E9 241 (AUG) 2 : 1

Digital Image Processing

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

Soma Biswas , Rajiv Soundararajan

Pre-requistes : None

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

E9 291 (AUG) 2 : 1

DSP System Design

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

Rathna G N

Pre-requistes : None

References : References: 1. Morrow, Michael G. Welch, Thad B. Wright, Cameron H. G - Real-Time Digital Signal Processing from MATLAB to C with the TMS320C6x DSPs, Third Edition-Chapman and Hall_CRC (2016) 2. Rulph Chassaing,Digital signal processing and applications with C6713 and C6416 DSK,Wiley,2005

E9 309 (AUG) 3 : 1

Advanced Deep Learning

Visual and Time Series Modeling: Semantic Models, Recurrent neural models and LSTM models, Encoder-decoder models, Atten-tion models. Representation Learning, Causality And Explainability:t-SNE visualization, Hierarchical Representation, semantic embeddings, gradient and perturba-tion analysis,Topics in Explainable learning, Structural causal models. Unsupervised Learning: Restricted Boltzmann Machines, Variational Autoencoders, Generative Adversarial Networks. New Architectures: Capsule networks, End-to-end models,Transformer Networks. Applications In NLP, Speech, Image/Video domains in all modules.

Sriram Ganapathy

Pre-requistes : None

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

EE 299 (AUG) 0 : 24

Project

MTech EE Project

Soma Biswas

Pre-requistes : None

References : None

SP 299 (AUG) 0 : 28

Project

MTech SP Project

Soma Biswas

Pre-requistes : None

References : None

Department of Electronic Systems Engineering
M Tech Electronic Systems Engineering

Duration: 2 Years			**Total Credits: 64**
Core Courses: 15 credits (All courses are compulsory)			
E0 284	2:1	Aug	Digital VLSI Circuits
E2 243	2:1	Aug	Mathematics for Electrical Engineers
E3 204	3:0	Jan	Fundamentals of MOS Analog Integrated Circuits
E3 235	2:1	Aug	Design for Analog Circuits
E3 257	2:1	Jan	Embedded System Design
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 Recoding 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

Department of Electronic Systems Engineering
M Tech Electronic Product Design

Duration: 2 Years			**Total Credits: 64**
Core Courses: 12 credits (All courses are compulsory)			
E3 258	2:1	Aug	Design for Internet of Things
E6 203	1:2	Aug	Mechatronics System Design
New	2:1	Jan	Design of analog electronics and industrial instrumentation
E3 257	2:1	Jan	Embedded System Design
Electives: 21 Credits (all at 200 level or higher) from the following courses or any other courses listed in the Scheme of Instructions.			
PD 215	2:1	Jan	Mechatronics (CPDM)
IN 221	3:0	Jan	Sensors and Transducers (IAP)
E2 232	2:1	Aug	TCP-IP Networking
E3 231	2:1	Jan	Digital System Design with FPGAs
IN 229	3:0	Aug	Advanced Instrumentation Electronics (IAP)
E3 276	2:1	Jan	Process Technology and System Engineering for Advanced Microsensors and Devices
NE 250	1:0	Aug	Entrepreneurship, Ethics and Societal Impact (CeNSE)
E6 202	2:1	Jan	Design of Power Converters
PD 229	0:3	Aug	Computer aided product design (CPDM)
E9 253	3:1	Jan	Neural Networks and Learning Systems
Project: 31 Credits			
EP 299	0:31		Dissertation Project

Departments of Electronic Systems Engineering and Electrical Communication Engineering
MTech Microelectronics and VLSI Design

Duration: 2 Years			**Total Credits: 64**
Core Courses: 18 credits, mandatory for all students.			
E0 284	2:1	Aug	Digital VLSI Circuit
E3 200	1:2	Jan/Aug	Microelectronics Lab
E3 220	3:0	Jan/Aug	Foundations of Nanoelectronics Devices
E3 231	2:1	Jan	Digital Systems Design with FPGAs
E3 238	2:1	Aug	Analog VLSI Circuits
E3 282	3:0	Jan/Aug	Basics of Semiconductor Devices and Technology
Electives: 18 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
E3 225	3:0	Aug	Art of Compact Modelling
E3 237	3:0	Jan	Integrated Circuits for Wireless Communication
E3 245	2:1	Aug	Processor System Design
E3 257	2:1	Jan	Embedded System Design
E3 271	1:2	Jan	Reliability of Nanoscale Circuits and Systems
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 Tech & System Eng for Adv Microsensors and Devices
E3 280	3:0	Jan	Carrier Transport in Nanoelectronics Devices
E3 301	3:0	Jan	Special topics in Nanoelectronics
E7 211	2:1	Jan	Photonic Integrated Circuits
E7 214	3:0	Jan	Optoelectronic Devices
E8 202	2:1	Aug	Computational Electromagnetics
E8 242	2:1	Jan	RF IC and Systems
E8 262	3:0	Jan	CAD for High Speed Chip-Package-Systems
NE 203	3:0	Aug	Advanced Micro and Nano Fabrication Tech and Process
NE 205	3:0	Aug	Semiconductor Devices and Integrated Circuit Technology
NE 215	3:0	Aug	Applied Solid State Physics
NE 222	3:0	Aug	MEMS: Modeling, Design, and Implementation
NE 241	3:0	Aug	Material Synthesis: Quantum Dots to Bulk Crystals
NE 202	0:1	Jan	Device Fabrication Lab Module (Micro and Nano Fabrication)
NE 201	2:1	Jan	Micro and Nano Characterization Methods
NE 314	3:0	Jan	Semiconductor Opto-electronics and Photovoltaics
NE 221	2:1	Jan	Advanced MEMS Packaging Lab: Packaging Lab
IN 221	3:0	Aug	Sensors and Transducers
IN 229	3:0	Aug	Advanced Instrumentation Electronics
IN 212	3:0	Jan	Advanced Nano/Micro Systems
IN 214	3:0	Jan	Semiconductor Devices and Circuits
IN 224	3:0	Jan	Nanoscience and Device Fabrication

MT 209	3:0	Aug	Defects in Materials
MT 213	3:0	Jan	Electronic Properties of Materials
PH 203	3:0	Aug	Quantum Mechanics-I
PH 208	3:0	Jan	Condensed Matter Physics-I
PH 352	3:0	Jan	Semiconductor Physics
PH 359	3:0	Jan	Physics at Nanoscale
MR 303	3:0	Aug	Nanomaterials Synthesis and Devices
MR 307	3:0	Jan	Thin Film, Nano Materials and Devices: Science and Engg
MR 308	2:1	Jan	Computational Modeling of Materials
Project: 28 Credits			
MV 299	00:28		Dissertation Project

E0 284 (AUG) 2 : 1

Digital VLSI Circuits

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

Chetan Singh Thakur

Pre-requistes : None

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

E2 232 (AUG) 2 : 1

TCP/IP Networking

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

Prabhakar T V , Dagale Haresh Ramji , Joy Kuri

Pre-requistes : None

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

E2 243 (AUG) 2 : 1

Mathematics for Electrical Engineers

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

Chandramani Kishore Singh

Pre-requistes : None

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

E3 200 (AUG) 1 : 2

Microelectronics Lab

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

Mayank Shrivastava

Pre-requistes : None

References : None

E3 235 (AUG) 2 : 1

Design for Analog Circuits

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

Naga Krishna V.

Pre-requistes : None

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

E3 245 (AUG) 2 : 1

Processor System Design

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

Kuruvilla Verghese

Pre-requistes : None

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

E3 258 (AUG) 2 : 1

Design for Internet of Things

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

Prabhakar T V

Pre-requistes : None

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

E3 282 (AUG) 3 : 0

Basics of Semiconductor Devices and Technology

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

Mayank Shrivastava

Pre-requistes : None

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

E9 253 (AUG) 3 : 1

Neural Networks and Learning Systems

Introduction, models of a neuron, neural networks as directed graphs, networkarchitectures (feed-forward, feedback etc.), Learning processes, learning tasks, Perceptron, perceptron convergence theorem, relationship between perceptron and Bayes classifiers, batch perceptron algorithm, modeling through regression: linear, logistic for multiple classes, Multilayer perceptron (MLP), batch and online learning, derivation of the back propagation algorithm, XOR problem, Role of Hessian in online learning, annealing and optimal control of learning rate, Approximations of functions, universal approximation theorem,cross-validation, network pruning and complexity regularization, convolution networks, nonlinear filtering, Cover's theorem and pattern separability, the interpolation problem, RBF networks, hybrid learning procedure for RBF networks, Kernel regression and relationship to RBFs., Support vector machines, optimal hyperplane for linear separability, optimal hyperplane for non- separable patterns, SVM as a kernel machine, design of SVMs, XOR problem revisited, robustness considerations for regression, 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

Pre-requistes : None

References : None

E3 260 (AUG) 2 : 1

Embedded System Design – II

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

Dagale Haresh Ramji

Pre-requistes : None

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

E6 203 (AUG) 1 : 2

Mechatronics System Design

Mechatronics intro, bond graph modelling of mechatronic systems, sensors and circuits - voltage, current, temperature, pressure, velocity, position, angular velocity, flow, flow rate, torque, stress, strain, etc., electrical actuators and drive - moving iron,solenoids, relays, electric motors, servo motor, stepper motor, motor selection, mechanical actuators - kinematic chains, cam, gears,ratchet, clutches, flexible elements, brakes etc., interfacing microcontrollers with actuators, control of actuators, robotic manipulator, differential dynamic mobile robot

Umanand L

Pre-requistes : None

References : 1. System dynamics: A unified approach, Dean Karnopp and Ronald Rosenberg, John Wiley and Sons 2. Mechatronics:Principles and Applications, Godfrey C Onwubolu, Elsevier publishers, 2005, 3.Digital control of dynamic systems, Franklin, Powell and Workman, Addison-Wesley, 3ed

Division of Mechanical Sciences

Preface

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

AE	Aerospace Engineering
AS	Atmospheric and Oceanic Sciences
CE	Civil Engineering
CH	Chemical Engineering
DC	Divecha Centre of Climate Change
ER	Earth Sciences
ME	Mechanical Engineering
MT	Materials Engineering
PD	Product Design and Manufacturing
ST	Sustainable Technologies

The first two letters of the course number indicate the departmental code. All the departments and centres (except the Space Technology Cell) of the Division provide facilities for research work leading to the degrees of MTech (Research) and PhD. There are specific requirements for completing a Research Training Programme (RTP) for students registered for research at the Institute. For individual requirements, students are advised to consult the Departmental Curriculum Committee (DCC). MTech Degree Programmes are offered in all the above departments except in the Centre for Product Design and Manufacturing, which offers Master of Design (MDes). Most of the courses are offered by the faculty members of the Division, but instruction by specialists in the field and experts from industries is arranged in certain topics.

Student feedback is important to maintain quality, breadth, and depth in courses. Hence, students are urged to actively participate in providing feedback after the completion of each course. Written comments are especially encouraged from the students in addition to marking the scores.

Prof. G. K. Ananthasuresh
Dean
Division of Mechanical Sciences

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 :

Semester I	Semester 2	Semester 3	Semester 4
Flight and Space Mechanics	**Math requirement** Either 2^{nd} or 3^{rd} semester		**Aerospace Seminar**
Fluid Dynamics	**Elective 1**	**Elective 5**	
Mechanics and Thermodynamics of Propulsion	**Elective 2**	**Elective 6**	
Flight Vehicle Structures	**Elective 3**	**Elective 7**	
Navigation, Guidance and Control	**Elective 4**	**Elective 8**	
Experimental Techniques in Aerospace Engineering		**MTech Dissertation** Distributed over 3^{rd} and 4^{th} semesters	
16 credits	48 credits (Minimum 12 credits per semester)		

Core courses

Aerospace Engineering

AE 201 (AUG) 3 : 0

Flight and Space Mechanics

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

Radhakant Padhi , Srisha Rao M V

Pre-requistes : None

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

AE 202 (AUG) 3 : 0

Fluid Dynamics

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

Duvvuri Subrahmanyam

Pre-requistes : None

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

AE 203 (AUG) 3 : 0

Mechanics and Thermodynamics of Propulsion

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

Pratikash Prakash Panda

Pre-requistes : None

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

AE 204 (AUG) 3 : 0

Flight Vehicle Structures

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

Debiprosad Roy Mahapatra

Pre-requistes : None

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

AE 205 (AUG) 3 : 0

Navigation, Guidance and Control

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

Ashwini Ratnoo , Suresh Sundaram

Pre-requistes : None

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

AE 225 (AUG) 3 : 0

Boundary Layer Theory

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

Sourabh Suhas Diwan

Pre-requistes : None

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

AE 245 (AUG) 3 : 0

Advanced Combustion

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

Santosh Hemchandra

Pre-requistes : None

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

AE 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

Pre-requistes : None

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

AE 261 (AUG) 3 : 0

Structural Vibration Control

Introduction to vibration control, passive and active vibration control. Concept of vibration isolation, dynamic vibration absorber, visco- elastic polymers as constrained and unconstrained configuration in passive vibration control. Constitutive modeling of structures with PZTs/PVDF materials, electro restrictive, magneto restrictive and shape memory alloys. Application of PZT patches, PVDF films, electro restrictive, magneto restrictive materials and shape memory alloys (SMA in structural vibration control.

Siddanagouda Kandagal

Pre-requistes : None

References : Nashif, D.N., Jones, D.I.G., and Henderson, J.P., Vibration damping, John Wiley, New York, 1985. .~Srinivasan, A.V., and McFarland, D.M., Smart Structures: Analysis and Design, Cambridge University Press, Cambridge, 2001. ~Inman, D.J., Vibration with Control, John Wiley, New York, 2006

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.

Irfan Ahmed Mulla

Pre-requistes : None

References : None

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.

Atmospheric and Oceanic Sciences

AS 203 (AUG) 3 : 0

Atmospheric Thermodynamics

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

Arindam Chakraborty

Pre-requistes : None

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

AS 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.

Satheesh S K

Pre-requistes : None

References : None

AS 207 (AUG) 3 : 0

Introduction to Atmospheric Dynamics

Jai Suhas Sukhatme

Pre-requistes : None

References : None

AS 313 (AUG) 3 : 0

Non-Linear Model in Climate Sciences

Ashwin K Seshadri

Pre-requistes : None

References : An introduction to nonlinear dynamics (Linearization; Bifurcation theory; Chaos and predictability; Measuring chaotic dynamics); Model reduction techniques (Galerkin, POD, etc.); Review of low-order models (LOMs): energy balance, ice sheet dynamics, convection, general circulation, ENSO, ocean models; Coupled ocean-atmospheric LOMs; Numerical analysis of nonlinear models

AS 215 (AUG) 3 : 0

Environmental Fluid Dynamics

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

Bishakhdatta Gayen

Pre-requistes : None

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

CIVIL ENGINEERING

Scheme of Instruction for M Tech Civil Engineering program (2021-22)

M Tech Program in Civil Engineering

Semester 1 Common to all students
Core: 18 Credits
CE 201 3:0 Basic Geomechanics
CE 275 3:0 Transportation Systems Modelling
CE 217 3:0 Fluid Mechanics
CE 204 3:0 Solid Mechanics
CE 205 3:0 Finite Element Method
CE 211 3:0 Mathematics for Engineers

a) **To fulfill Major requirement in an Area,** students shall complete minimum 21 course credits (15 core + 6 elective on offer) and 22 Dissertation project credits in the said Area.
b) **For optional Minor in one of the other four Areas**, a student must complete minimum of 12 credits in the said Area.

Major in Dam Engineering

Core: 12 Credits (+ 3 credits from term 1)
CE $$$ 3:0 Disaster Management for Dams
CE $$$ 3:0 Dam Safety Surveillance, Instrumentation and Monitoring (From Aug 2022)
CE 260 3:0 Rock mechanics (From Aug 2022)
CE $$$ 1:2 Integrated Investigation of Dams (From Aug 2022)
CE 299 0:22 Dissertation Project

Major in Geotechnical Engineering

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

Major in Structural Engineering

Core: 9 Credits (+ 6 credits from term 1)
CE 209 3:0 Mechanics of Structural Concrete
CE 210 3:0 Structural Dynamics
CE 228 3:0 Continuum Plasticity
CE 299 0:22 Dissertation Project

Major in Water Resources Engineering

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

Major in Transportation Systems Engineering

Core: 12 Credits (+ 3 credits from term 1)
CE 262 3:0 Public Transportation Systems Planning
CE 272 3:0 Traffic Network Equilibrium
CE 235 3:0 Optimization Methods
CE 299 0:22 Dissertation Project

Electives in Dam Engineering

CE $$$ 3:0 Assessing and Managing Risks Associated with Dams (From Aug 2022)
CE $$$ 3:0 Sediment Management in Reservoirs
CE $$$ 3:0 Hydrologic Safety Evaluation of Dams (From Aug 2022)
CE $$$ 3:0 Dams and Spillways (From Aug 2022)
CE 206 3:0 Earth Retaining Structures and Earthen Dams
CE 208 3:0 Ground Improvement and Geosynthetics
CE 221 3:0 Earthquake Geotechnical Engineering
CE 227 3:0 Engineering Seismology
CE 279 3:0 Computational Geotechnics
CE $$$ 3:0 Flood Resilient Transport System (From Aug 2022)
ST $$$ 3:0 Basic Concepts of Planning & Design of Hydro-Mechanical Components in Dams

Electives in Geotechnical Engineering

CE 220 3:0 Design of Substructures
CE 221 3:0 Earthquake Geotechnical Engineering
CE 227 3:0 Engineering Seismology
CE 231 3:0 Forensic Geotechnical Engineering
CE 279 3:0 Computational Geotechnics

Electives in Structural Engineering
CE 229 3:0 Non-Destructive Evaluation Methods for Concrete Structures
CE 235 3:0 Optimization Methods
CE 236 3:0 Fracture Mechanics
CE 239 3:0 Stochastic Structural Dynamics
CE 240 3:0 Uncertainty Modeling and analysis
CE 243 3:0 Bridge Engineering
CE 250 3:0 Stability and Design of Steel Structures
CE 280 3:0 Structural System Identification

CE 284 3:0 Plates, Shells, and Geometric Elasticity

Electives in Water Resources Engineering
CE 223 3:0 Hydroclimatology
CE 226 3:0 Open Channel Flow
CE 247 3:0 Remote Sensing and GIS for Water Resources Engineering
CE 249 3:0 Water Quality Modelling
CE 277 3:0 Remote Sensing in Ecohydrology
CE $$$ 3:0 Hydrologic Safety Evaluation of Dams (From Aug 2022)
AS 216 3:0 Introduction to Climate Systems

Electives in Transportation Systems Engineering
CE 269 3:0 Traffic Engineering
CE 271 3:0 Choice Modelling
CE $$$ 3:0 Flood Resilient Transport System (From Aug 2022)
DS 290 3:0 Modelling and Simulation
ST 203 3:0 Technology and Sustainable Development
MG 221 3:0 Applied Statistics

CE 247 (AUG) 3 : 0

Remote Sensing and GIS for Water Resources Engineering

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

Nagesh Kumar D

Pre-requistes : None

References : Remote Sensing and Image Interpretation, T.M. Lillesand and R.W. Kiefer, John Wiley & Sons, 2000.~Remote Sensing - Principles and Interpretation, F.F. Sabins Jr, W.H. Freeman & Co., New York, 1986.~An Introduction to Geographical Information Systems, I. Heywood, S.Cornelius and S.Carver, Pearson Education, 1998.~Remote sensing in water resources management: The state of the art,

CE 201 (AUG) 3 : 0

Basic Geo-mechanics

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

Swetha Veeraraghavan

Pre-requistes : None

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

CE 204 (AUG) 3 : 0

Solid Mechanics

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

Narayan K Sundaram

Pre-requistes : None

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

CE 211 (AUG) 3 : 0

Mathematics for Engineers

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

Manohar C S

Pre-requistes : None

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

CE 220 (AUG) 3 : 0

Design of Substructures

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

Raghuveer Rao Pallepati

Pre-requistes : None

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

CE 221 (AUG) 3 : 0

Earthquake Geotechnical Engineering

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

Gali Madhavi Latha

Pre-requistes : None

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

CE 226 (AUG) 3 : 0

Open-channel Flow

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

Rajarshi Das Bhowmik

Pre-requistes : None

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

CE 236 (AUG) 3 : 0

Fracture Mechanics

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

Remalli Vidya Sagar

Pre-requistes : None

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

CE 240 (AUG) 3 : 0

Uncertainty Modeling and Analysis

Deterministic vs nondeterministic perspectives. Sources of uncertainty. Epistemic vs. aleatoric uncertainty. Data driven vs. physics driven uncertainty modelling. Different approaches such as probabilistic, interval, fuzzy. Introductory probability and statistics, point estimation, hypothesis testing, time series. Modelling: connecting data to the probabilistic models. Discretization of random fields. Tools for uncertainty propagation. Computational aspects of uncertainty propagation.

Debraj Ghosh

Pre-requistes : None

References : None

CE 243 (AUG) 3 : 0

Bridge Engineering

Ananth Ramaswamy

Pre-requistes : None

References : None

CE 249 (AUG) 3 : 0

Water Quality Modeling

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

Sekhar M

Pre-requistes : None

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

CE 269 (AUG) 3 : 0

Traffic Engineering

Traffic flow elements and its characterization: vehicle characteristics, human factors, infrastructure elements, capacity and LoS concepts, Highway Capacity Manual (HCM) methods. Uninterrupted Traffic Flow: speed-flow-density relationships, multi-regime models, car-following, lane-changing, simulation framework. Interrupted Traffic Flow: signal design, shock-wave theory, gap-acceptance behavior, delay and queue analysis. Design of traffic facilities:expressways, signalized and un- signalized intersections, interchanges, parking, signs and markings.

Tarun Rambha

Pre-requistes : None

References : Roess, R.P., Prassas E.S. & McShane, W.R. (2010), Traffic Engineering, Prentice Hall, USA.~May, A. D. (1990), Traffic Flow Fundamentals, Prentice Hall, USA.~Highway Capacity Manual (2010), Transportation Research Board, USA.~Kadiyali, L. R. (2000), Traffic Engineering and Transport Planning, Khanna Publishers, India.~Salter, R J. & Hounsell, N. B. (1996), Highway Traffic Analysis and Design,

CE 274 (AUG) 3 : 0

Sustainable Urban Transportation Planning

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

Ashish Verma

Pre-requistes : None

References : Gudmundsson H; Hall RP; Marsden G; Zietsman J (2015) Sustainable Transportation Indicators, Frameworks, and Performance Management, Springer. A. Gautam et al. (eds.), Sustainable Energy and Transportation, Springer, pp.9-20.~Verma A., (2012), "Quantifying Sustainability to Assess Urban Transportation Policies and Projects". Indian Journal of Transport Management,Vol.36,

CE 290 (AUG) 3 : 0

Structural System Identification

Manohar C S

Pre-requistes : None

References : None

CE 217 (AUG) 3 : 0

Fluid Mechanics

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

Debsunder Dutta

Pre-requistes : None

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

CE 275 (AUG) 3 : 0

Transportation Systems Modelling

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

Abdul Rawoof Pinjari

Pre-requistes : None

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

Dept of Chemical Engineering

Courses in the Department : August 2021

August Semester			January Semester		
CH 201	3:0	Engineering Mathematics	CH205	3:0	Chemical Reaction Engineering
CH 202	3:0	Numerical Methods	CH 207	1:0	Applied Statistics & design of Experiments
CH 203	3:0	Transport Phenomena	CH 232	3:0	Physics of Fluids
CH 204	3:0	Thermodynamics	CH 234	3:0	Rheology of Complex Fluids
CH 206	1:0	Seminar	CH 236	3:0	Statistical Thermodynamics
CH 235	3:0	Modelling in Chemical Engineering	CH 243	3:0	Mechanics of Particle Suspensions
CH 242	3:0	Special Topics in Theoretical Biology	CH 245	3:0	Interfacial and Colloidal Phenomena
CH 244	3:0	Treatment of Drinking Water	CH 247	3:0	Introduction to Molecular Simulations
CH 248	3:0	Molecular Systems Biology	CH 249	3:0	Structural and Functional DNA Nanotechnology
CH 299	0:32	Dissertation Project (M Tech)			

The detailed contentof 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.

Programme	Credits	DepartmentRequirements
M Tech Programme, duration 2 years	64	Course work of 32 creditsincludes 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.
M Tech (Res) Programme	12	CH 201 or CH 202, anda 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.
PhD Programme, after Bachelor's degree	24	CH 201 to 207 are compulsory. A maximum of 33 credits is permitted.
PhD Programme, after Master's degree	12	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.

Chemical Engineering

CH 201 (AUG) 3 : 0

Engineering Mathematics

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

Ganapathy Ayappa , Ananth Govind Rajan

Pre-requistes : None

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

CH 202 (AUG) 3 : 0

Numerical Methods

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

Bhushan J Toley

Pre-requistes : None

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

CH 203 (AUG) 3 : 0

Transport Processes

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

Kumaran V

Pre-requistes : None

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

CH 204 (AUG) 3 : 0

Thermodynamics

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

Sudeep Punnathanam

Pre-requistes : None

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

CH 206 (AUG) 1 : 0

Seminar Course

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

Venugopal S , Rahul Roy

Pre-requistes : None

References : None

CH 235 (AUG) 3 : 0

Modeling in Chemical Engineering

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

Sanjeev Kumar Gupta

Pre-requistes : None

References : Lecture notes

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 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.

Sanjeev Kumar Gupta , Sudeep Punnathanam

Pre-requistes : None

References : None

Dept of Mechanical Engineering

M Tech Program
Duration:2 years
Total: 64 credits

Soft Core courses (4 out of 5)

ME201	3:0 Fluid Mechanics
ME228	3:0 Materials and Structure Property Correlations
ME240	3:0 Dynamics& Controlof Mechanical Systems
ME242	3:0 Solid Mechanics
ME271	3:0 Thermodynamics

(Soft Core) Math requirement

ME 261 3:0 Engineering Mathematics
OR
AE211 3:0 Mathematical Methods for Aerospace engineers

Seminar Course requirement

ME297 1:0SeminarCourse

Project : 27Credits
ME2990:27Dissertation Project

Electives:7 Courses (21credits).

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

(Soft Core) Math requirement
ME 261 3:0 Engineering Mathematics
OR
AE 211 3:0 Mathematical Methods for Aerospace engineers

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

(Soft Core) Math requirement
ME 261 3:0 Engineering Mathematics
OR

AE 211 3:0 Mathematical Methods for Aerospace engineers

Mechanical Engineering

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 , Aloke Kumar

Pre-requistes : None

References : None

ME 228 (AUG) 3 : 0

Materials and Structure Property Correlations

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

Koushik Viswanathan

Pre-requistes : None

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

ME 240 (AUG) 3 : 0

Dynamics and Control of Mechanical Systems

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

Jayanth G R , Jishnu Keshavan

Pre-requistes : None

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

ME 242 (AUG) 3 : 0

Solid Mechanics

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

Chandrashekhar S Jog

Pre-requistes : None

References : None

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

Pre-requistes : None

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

ME 250 (AUG) 3 : 0

Structural Acoustics

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

Venkata R Sonti

Pre-requistes : None

References : None

ME 255 (AUG) 3 : 0

Principles of Tribology

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

Bobji M S

Pre-requistes : None

References : None

ME 261 (AUG) 3 : 0

Engineering Mathematics

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

Venkata R Sonti , Gaurav Tomar , Koushik Viswanathan

Pre-requistes : None

References : None

ME 271 (AUG) 3 : 0

Thermodynamics

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

Ravikrishna R V , Navaneetha Krishnan Ravichandran

Pre-requistes : None

References : None

ME 285 (AUG) 3 : 0

Turbomachine Theory

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

Raghuraman N Govardhan

Pre-requistes : None

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

ME 289 (AUG) 3 : 0

Principles of Solar Thermal Engineering

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

Narasimham G S V L

Pre-requistes : None

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

ME 290 (AUG) 3 : 0

Mechanics of slender elastic structures

Ramsharan Rangarajan

Pre-requistes : None

References : None

ME 297 (AUG) 1 : 0

Departmental Seminar

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

Navaneetha Krishnan Ravichandran

Pre-requistes : None

References : None

ME 259 (AUG) 3 : 0

Nonlinear Finite Element Methods

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

Narasimhan R

Pre-requistes : None

References : Bathe, K.J., Finite Element Procedures, Prentice Hall of India, New Delhi 1997. ~Zienkiewicz, O.C., and Taylor, R.L., The Finite Element Method, Vols. I and II, McGraw Hill, 1991.~Belytshko, T., Liu, W.K., and Moran, B., Nonlinear Finite Elements for Continua and Structures, Wiley, 2000.~Simo, J.C. and Hughes, T.J.R., Computational Inelasticity, Springer, 1998.

ME 260 (AUG) 3 : 0

Structural Optimiztion:Size, Shape, and Topology

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

Ananthasuresh G K

Pre-requistes : None

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

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.

Materials Engineering

MT 202 (AUG) 3 : 0

Thermodynamics and Kinetics

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

Sai Gautam Gopalakrishnan

Pre-requistes : None

References : C.H.P. Lupis: Chemical Thermodynamics of Materials, Elsevier Science, 1982~P.Shewmon: Diffusion in Solids, 2nd Edition, Wiley, 1989.~A.W. Adamson and A.P.Gast: Physical Chemistry of Surfaces (Sixth Edition), John Wiley, 1997.

MT 206 (AUG) 3 : 0

Texture and Grain Boundary Engineering

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

Satyam Suwas

Pre-requistes : None

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

MT 209 (AUG) 3 : 0

Defects in Materials

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

Karthikeyan Subramanian

Pre-requistes : None

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

MT 218 (AUG) 2 : 1

Modeling and Simulation in Materials Engineering

Govind S Gupta , Praveen Ramamurthy , Rajeev Ranjan , Praveen Kumar , Suryasarathi Bose , Abhik N Choud

Pre-requistes : None

References : None

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

Pre-requistes : None

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

MT 243 (AUG) 0 : 2

Laboratory Experiments in Materials Engineering

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

Rajeev Ranjan

Pre-requistes : None

References : None

MT 245 (AUG) 3 : 0

Transpoert processes in Process Metallurgy

Govind S Gupta

Pre-requistes : None

References : None

MT 253 (AUG) 3 : 0

Mechanical Behaviour of Materials

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

Praveen Kumar

Pre-requistes : None

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

MT 260 (AUG) 3 : 0

Polymer Science and Engineering

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

Suryasarathi Bose

Pre-requistes : None

References : None

MT 261 (AUG) 3 : 0

Organic Electronics

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

Praveen Ramamurthy

Pre-requistes : None

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

Product Design and Manufacturing

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

Pre-requistes : None

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

MN 202 (AUG) 3 : 0

Digital Manufacturing

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

Ashitava Ghosal , Gurumoorthy B , Dibakar Sen

Pre-requistes : None

References : None

PD 201 (AUG) 2 : 1

Elements of Design

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

Vishal Singh

Pre-requistes : None

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

PD 202 (AUG) 2 : 1

Elements of Solid and Fluid Mechanics

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

Gurumoorthy B

Pre-requistes : None

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

PD 203 (AUG) 2 : 1

Creative Engineering Design

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

Amaresh Chakrabarti

Pre-requistes : None

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

PD 207 (AUG) 1 : 2

Product Visualization, Communication and Presentation

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

Shivakumar N D

Pre-requistes : None

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

PD 209 (AUG) 2 : 1

New Product Development: Concepts and Tools

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

Gurumoorthy B

Pre-requistes : None

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

PD 217 (AUG) 2 : 1

CAE in Product Design

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

Anindya Deb

Pre-requistes : None

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

PD 229 (AUG) 0 : 3

Computer Aided Product Design

Product modelling, Process Modelling, Intelligent machines, Autonomous devices in manufacturing, Interoperability of digital models in manufacturing,computer aided inspection and verification, Digital Thread and applications of digital models in maintenance and operations Analysis of stress and strain, failure criteria, dynamics and vibrations. Control of engineering systems, elements of fluid mechanics drag and losses, thermal analysis, problems in structural and thermal design. Project in re-engineering a product using computer tools for reverse engineering geometry and intent, design evaluation, modification and prototyping.

Ashitava Ghosal , Gurumoorthy B

Pre-requistes : None

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

PD 231 (AUG) 2 : 1

Applied Ergonomics

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

Dibakar Sen

Pre-requistes : None

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

PD 232 (AUG) 2 : 1

Human Computer Interaction

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

Pradipta Biswas

Pre-requistes : None

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

PD 233 (AUG) 2 : 1

Design of Biomedical Devices and Systems

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

Manish Arora

Pre-requistes : None

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

PD 239 (AUG) 0 : 3

Design and Society

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

Dibakar Sen

Pre-requistes : None

References : None

PD 204 (AUG) 2 : 1

Basics of Electronics for Product Design and Manufacturing

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

Rina Maiti , Manish Arora , Abhijit Biswas

Pre-requistes : Students without electrical or electronics or instrumentation or similar background perusing higher study in interdisciplinary fields are encouraged to take this course. If a student with such background for any specific reason is interested in crediting this course please contact the course instructor(s) before registering for it.

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

PD 206 (AUG) 2 : 1

Basics of Computing, AI and Data Science for Desig

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

Pradipta Biswas , Vishal Singh , Abhijit Biswas

Pre-requistes : Students without computer science or data science or information technology or similar background perusing higher study in interdisciplinary fields are encouraged to take this course. If a student with such background for any specific reason is interested in crediting this course please contact the course instructor(s) before registering for it.

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

MN 207 (AUG) 2 : 1

Intelligent Mobile Robots: Perception, Action and Control

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

Abhra Roy Chowdhury

Pre-requistes : Familiarity with following is desired but not essential • Linear Algebra; Ordinary Differential Equations; Probability • Basic Mechanics, Dynamics and Control Systems for Mechanical systems • Basic Electronics • Programming in C or MATLA

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

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 T V

Pre-requistes : None

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

ST 216 (AUG) 3 : 0

Physics in Experiments with Classical Statistics

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

Punit Singh

Pre-requistes : None

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

ST 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

Pre-requistes : None

References : None

ST 219 (AUG) 3 : 0

Separation Technologies for Sustainable Industrial Processes

Consider any product that you use from the time you wake up till the end of the day - plastics, paper, pharmaceuticals, soaps and detergents, textiles, and many more. In this course, we focus on an important set of steps in the manufacture of such items that are critical in our daily lives, namely the ‘chemical separation’ steps. Such chemical separations typically account for 40-70% of the total cost of the complete manufacture process of the item. Cumulatively, separations in various industries add up to 15% of the world’s energy requirements. However, chemical separations and the concerned separation technologies are responsible for several important processes, such as extracting the final product from the synthesis medium; treating effluent streams before environmental discharge; recovering materials that can be reused for subsequent manufacture cycles; or isolating valuable intermediate products that can be used in a different industry, or sold. A few examples of chemical separations in industries are: carbon dioxide capture from flue gas, separation of synthesized pharmaceutical molecules from harmful reaction byproducts, ethanol-water separation after sugar fermentation for bioethanol production, and removal of heavy metals from industrial waste water to be reused or discharged. The most widely used separation technology today is distillation, accounting for 90% of industrial separations. This technology involves evaporation of certain species from a mixture and therefore, in several cases, requires high energy input (and therefore carbon dioxide footprint) compared to other technologies such as membrane separations or adsorption where phase changes can be avoided. In this course, we study several separation techniques such as distillation, membrane separations, adsorption, absorption, and liquid-liquid extraction. The course will cover the operating mechanisms, basic design methods, thermo-economic analysis, and ecological impact evaluation of these separation techniques, in order to select and design the optimal sustainable separation solution for a given practical problem

Yagnaseni Roy

Pre-requistes : None

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

ST 218 (AUG) 3 : 0

Sustainable Wastewater Management

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

Sreenivasan Ramaswami

Pre-requistes : None

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

Centre for Earth Sciences

The Centre for Earth Sciences offers three post-undergraduate 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 3:0 Introduction to Petrology (AUG)
ES 204 3:0 Origin and Evolution of the Earth (AUG)
ES 205 3:0 Mathematics for Geophysicists (AUG)
ES 206 3:0 Solid Earth Geophysics (AUG)
ES 215 3:0 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 204 (AUG) 3 : 0

Origin and Evolution of the Earth

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

Ramananda Chakrabarti

Pre-requistes : None

References : Charles H. Langmuir and Wally Broecker, How to build a habitable planet, Revised and expanded edition, Princeton University Press, 2012;~A. P. Dickin, Radiogenic Isotope Geology, Cambridge University Press, 1995;~John D. Winter, Principles of Igneous and Metamorphic Petrology, 2nd edition, Pearson Prentice Hall, 2010,

ES 205 (AUG) 3 : 0

Mathematics for Geophysicists

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

Binod Sreenivasan

Pre-requistes : None

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

ES 215 (AUG) 3 : 0

Introduction to Chemical Oceanography

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

Sambuddha Misra

Pre-requistes : None

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

ES 206 (AUG) 3 : 0

Solid Earth Geophysics

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

Attreyee Ghosh

Pre-requistes : None

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

ES 217 (AUG) 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

Pawan Bharadwaj Pisupati

Pre-requistes : None

References : Fowler, C.M.R., The solid earth: An Introduction to Global Geophysics, Cambridge University Press, 2005. W. Lowrie and A. Fichtner, Fundamentals of Geophysics (3rd edition), Cambridge University Press, 2020.

Division of Interdisciplinary Sciences

Preface

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

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

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

Prof. Navakanta Bhat
Dean
Division of Interdisciplinary Sciences

BioSystems Science and Engineering

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

Core Courses: 9 Credits

BE 203	0:1	Bioengineering practicum 1
BE 204	0:1	Bioengineering practicum 2
BE 207	3:0	Mathematical Methods for Bioengineers
BE 213	2:0	Fundamentals of Bioengineering 1
BE 214	2:0	Fundamentals of Bioengineering 2

Soft core (for students from engineering background who have not taken Biology after school)

BE 206	3:0	Biology for Engineers

Electives offered by department

BE 209	1:0	Digital Epidemiology
BE 210	3:0	Drug Delivery
BE 211	3:0	Cell Mechanics
BE 215	3:0	Chemistry for Bioengineers
BE 217	3:0	Introduction to Disease Modeling

BE 203 (AUG) 0 : 1

Bioengineering Practicum 1

Rachit Agarwal

Pre-requistes : None

References : None

BE 204 (AUG) 0 : 1

Bioengineering Practicum 2

Rachit Agarwal

Pre-requistes : None

References : None

BE 206 (AUG) 3 : 0

Biology for Engineers

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

Siddharth Jhunjhunwala

Pre-requistes : None

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

BE 210 (AUG) 3 : 0

Drug Delivery: Principles and Applications

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

Pre-requistes : None

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

BE 214 (AUG) 2 : 0

Fundamentals of Bioengineering 2

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

Siddharth Jhunjhunwala

Pre-requistes : None

References : Biology: Concepts and Connections, Third Edition. Campbell, Mitchell and Reece.~Molecular Biology of the Cell, Fourth Edition. B. Alberts, A. Johnson, J.Lewis, M. Raff, K. Roberts and P. Walter Biomaterials Science, B.D. Ratner et. al., 3rd Edition, Academic Press,2012. ~A Textbook of Biomechanics, S. Pal, Viva Books, New Delhi,India, 2009~An Introduction to Biomechanics, J. D. Humphrey

BE 217 (AUG) 3 : 0

Introduction to Disease Modeling

The course will focus on system physiology modeling of various disease states. The course will cover relevant network construction through data mining, Ddevelopment of the mathematical model, integrating data at several levels, omics to clinical, to benchmark the model, and integrate pharma-cokinetic and pharmacodynamic clinical data to construct an end-to-end characterization of the disease state to available drugs. Parametric and initial condition sensitivity analysis will be covered. What-if scenarios, such as genetic mutations or SNPs, along with population variability will also be considered.The course will be run in a project mode, wherein a student will pick a disease and go through the complete steps of building a validated model and use it for analysis. Relevant lectures will be given to provide concepts and methods with example. Most of the instruction will be one on one with the student to help develop the disease model

Mohit Kumar Jolly

Pre-requistes : No pre-requisites; PhD, M.Tech, UGs can take the course, but there will be a cap on number of students in the course due to heavy weightage on course project.

References : The reference material for the course will be several published papers.

Energy Research

ER 201 (AUG) 3 : 0

Renewable Energy Technologies

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

Pradip Dutta

Pre-requistes : None

References : None

Computational and Data Sciences

M Tech Programme

Duration: 2 years

64 Credits

Course structure:

Hard Core: 14 credits

Hard Core Courses: 13 credits

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 226 AUG 2:1 Introduction to Computing for AI & Machine Learning

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-requistes : None

References : None

DS 201 (AUG) 2 : 0

Bioinformatics

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

Sekar K , Debnath Pal

Pre-requistes : None

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

DS 211 (AUG) 3 : 0

Numerical Optimization

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

Deepak Narayanan Subramani

Pre-requistes : None

References : None

DS 221 (AUG) 3 : 1

Introduction to Scalable Systems

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

Matthew Jacob T , Sathish S Vadhiyar , Chirag Jain

Pre-requistes : None

References : None

DS 263 (AUG) 3 : 1

Video Analytics

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

Venkatesh Babu R , Anirban Chakraborty

Pre-requistes : None

References : Richard Szeliski, Computer Vision: Algorithms and Applications, Springer 2010~Forsyth, D.A., and Ponce, J., Computer Vision: A Modern Approach, Pearson Education, 2003.~Current Literature

DS 284 (AUG) 2 : 1

Numerical Linear Algebra

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

Phani Sudheer Motamarri

Pre-requistes : None

References : None

DS 288 (AUG) 3 : 0

Numerical Methods

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

Phaneendra Kumar Yalavarthy

Pre-requistes : None

References : None

DS 290 (AUG) 3 : 0

Modelling and Simulation

Soumyendu Raha

Pre-requisites : None

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

DS 226 (AUG) 2 : 1

Introduction to Computing for AI and Machine Learning

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

Sashikumaar Ganesan

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

References : 1.John Hennessy David Patterson. Computer Architecture. A Quantitative Approach. 6th edition, Morgan Kauffman, 2017. https://www.elsevier.com/books/computer-architecture/hennessy/978-0-12- 811905-1 2.Shaw, Zed A. Learn python 3 the hard way: A very simple introduction to the terrifyingly beautiful world of computers and code. Addison- Wesley Professional, 2017. 3.Aurélien Géron, Hands-

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.

Nanoscience and Engineering

NE 201 (AUG) 2 : 1

Micro and Nano Characterization Methods

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

Akshay K Naik

Pre-requistes : None

References : None

NE 203 (AUG) 3 : 0

Advanced micro and nanofabrication technology and process

This is a foundation level optics course which intends to prepare students to pursue advanced topics in more specialized areas of optics such as biophotonics, nanophotonics, non-linear optics etc. Classical and quantum descriptions of light, diffraction, interference, polarization. Fourier optics, holography, imaging, anisotropic materials, optical modulation, waveguidesand fiber optics, coherence and lasers, plasmonics.Introduction and overview of micro and nano fabrication technology. Safety and contamination issues in a cleanroom. Overview of cleanroom hazards. Basic process flow structuring. Wafer type selection and cleaning methods. Additive fabrication processes. Material deposition methods. Overview of physical vapour deposition methods (thermal, e-beam, molecular beam evaporation) and chemical vapour deposition methods (PE-CVD, MOCVD, CBE, ALD). Pulsed laser deposition (PLD), pulsed electron deposition (PED). Doping: diffusion and ion implant techniques. Optical lithography

Sushobhan Avasthi

Pre-requistes : None

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

NE 213 (AUG) 3 : 0

Introduction to Photonics

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

Shankar Kumar Selvaraja

Pre-requistes : None

References : None

NE 215 (AUG) 3 : 0

Applied Solid State Physics

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

Akshay K Naik

Pre-requistes : None

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

NE 222 (AUG) 3 : 0

MEMS: Modeling, Design, and Implementation

This course discusses all aspects of MEMS technology–from modeling, design,fabrication, process integration, and final implementation. 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 asbulk 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 dicussed.

Saurabh Arun Chandorkar

Pre-requistes : None

References : G.K.Ananthasuresh,K.J.Vinoy,S. Gopalakrishnan,K.N.Bhat and V.K.Aatre. "Micro and Smart Systems- Technology and Modelling" John Wiley & Sons,Inc (2012)

NE 231 (AUG) 3 : 0

Microfluidics

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

Prosenjit Sen

Pre-requistes : None

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

NE 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 aimof this course is to introduce the student to the principles that help control growth. Crystallography ; Surfaces and Interfaces; Thermodynamics, Kinetics,and Mechanisms of Nucleation and Growth of Crystals ; Applications to growth from solutions, melts and vapors (Chemical vapor deposition an Physical vapor deposition methods); Stress effects in film growth

Pavan Nukala

Pre-requistes : None

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

NE 250 (AUG) 1 : 0

Entrepreneurship, Ethics and Societal Impact

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

Navakanta Bhat

Pre-requistes : None

References : None

NE 316 (AUG) 3 : 0

Advanced Electron Microscopy in Materials Characterization

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

Pavan Nukala

Pre-requistes : MR306 Electron Microscopy in Materials Characterization

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

NE 206 (AUG) 3 : 0

Semiconductor Device Physics: Basic Devices

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

Sushobhan Avasthi

Pre-requistes : None

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

Dept of Management Studies

Master of Management (M.Mgt) Program

Duration: 2 years

HardCore: 24 credits

MG201 3:0 Managerial Economics
MG211 3:0 HumanResourceManagement
MG212 2:1 BehavioralScience
MG221 2:1 AppliedStatistics
MG232 3:0 PrinciplesofManagement
MG241 3:0 MarketingManagement
MG251 3:0 Finance&Accounts
MG261 3:0 OperationsManagement

StreamCore:12Credits(tobechosenfromeitheroneofthetwostreams)

Stream1:BusinessAnalyticsStream

MG223 3:0 AppliedOperationsResearch
MG225 3:0 DecisionModels
MG226 3:0 TimeSeriesAnalysisand Forecasting
MG265 2:1 DataMining

Stream2:TechnologyManagementStream

MG271 3:0 TechnologyManagement
MG274 3:0 ManagementofInnovationand IntellectualProperty
MG281 3:0 ManagementofTechnologyfor Sustainability
MG298 2:1 EntrepreneurshipforTechnologyStart-ups

Electives:12credits

Project: :**MG299 0:16 Management Project**

Summer Internship: No credits. Every student is required to spend a minimum of eight weeks in an identified industrial enterprise or public sector organization during the summer period after the first two semesters. Alternatively students have the option to get exposure to business incubators,venture capital firms and successful start-ups.

Management Studies

MG 261 (AUG) 3 : 0

Operations Management

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

Mathirajan M

Pre-requistes : None

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

MG 201 (AUG) 3 : 0

Managerial Economics

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

Bala Subrahmanya Mungila Hillemane

Pre-requistes : None

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

MG 202 (AUG) 3 : 0

Macroeconomics

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

Bala Subrahmanya Mungila Hillemane

Pre-requistes : None

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

MG 212 (AUG) 2 : 1

Behavioral Science

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

Anjula Gurtoo

Pre-requistes : None

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

MG 221 (AUG) 2 : 1

Applied Probability and Statistics

Probability spaces, laws and calculations; distributions and moments of discrete and continuous univariate and multivariate random variables and vectors; binomial, Poisson, negative binomial, uniform, normal and gamma models. Poisson processes. Criteria and methods of estimation – UMVU, MM, ML. Testing statistical hypotheses – fixed and observed significance level testing. One and two sample problems for mean, variance and proportions – Z-test, t-test, chi-square-test, F-test, sign test, Wilcoxon rank–sum and signed-rank test. Chi-square-test of homogenity, independence and goodness-of-fit.

Mukhopadhyay C

Pre-requistes : None

References : Douglas C. Montgomery & George C. Runger,Applied Statistics and Probability for Engineers,Wiley India Pvt. Ltd.,Fifth Edition,2014

MG 225 (AUG) 3 : 0

Decision Models

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

Parthasarathy Ramachandran

Pre-requistes : None

References : None

MG 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 .

Pre-requistes : None

References : Harold Koontz and Heinz Weihrich,Essentials of Management – An International Perspective,Tata McGraw Hill Education Pvt. Ltd.,New Delhi,8th Edition

MG 241 (AUG) 3 : 0

Marketing Management

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

Parthasarathy Ramachandran

Pre-requistes : None

References : None

MG 242 (AUG) 3 : 0

Strategic Management

Parthasarathy Ramachandran

Pre-requistes : None

References : None

MG 246 (AUG) 3 : 0

Customer Segmentation and Insights

Develop a deep actionable understanding of customers using a disciplined approach to give companies a competitive advantage using customer research,analytics and experimentation. Numeric data, language data and image data analysis, verbal and non-verbal communication skills, and presentation techniques. What is Customer Segmentation? How is it useful for organizations? What are Customer Insights? What are "product-out" verses "market-in"approaches? What is a "purchase journey?" What is Customer Experience Management? Illustrated with examples. How to get a holistic picture (360o view) of the customer base? Collecting quantitative and qualitative (emotions) data about customers. How is customer segmentation done using data analytics? Illustrative examples. What are the different stages in the purchase journey? How do we know which of these "touchpoints" are of value (moments of truth) to target customer segments? How does one benchmark with competition? Some practical approaches to connect with customers to get insights. Determining the "latent needs" of the customer by using image and language data (Voice of Customer), art of active listening and observing customer behavior. Developing the Kano Questionnaire, Conducting the Kano survey. Analyzing the Kano results including cross-tabulation of customer attributes, developing product/ service concepts (experiments), conducting a pilot, evaluating the effectiveness of the experiments. What are the tools available to deliver a differentiated customer experience at those "moments of truths?" How does "digital" play a role in enhancing customer experience?

Parthasarathy Ramachandran

Pre-requistes : None

References : None

MG 258 (AUG) 3 : 0

Financial instruments and risk management strategies

Shashi Jain

Pre-requistes : None

References : None

MG 265 (AUG) 3 : 0

Data Mining

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

Parthasarathy Ramachandran

Pre-requistes : None

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

CP 212 (AUG) 2 : 1

Design of Cyber-Physical Systems

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

Shishir Nadubettu Yadukumar

Pre-requistes : None

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

CP 214 (AUG) 3 : 1

Foundations of Robotics

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

Shishir Nadubettu Yadukumar

Pre-requistes : None

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

CP 220 (AUG) 2 : 1

Mathematical Techniques for Robotics Systems

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

Bharadwaj Amrutur

Pre-requistes : None

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