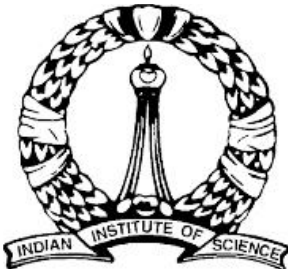
Scheme of Instruction 2014-15



Indian Institute of Science
Bangalore - 560 012

Contents

SCHEME OF INSTRUCTION
2014-15

Preface

The “Scheme of Instruction and Student Information Handbook” contains of the courses and rules and regulations related to studnet life.

The course listings are provided in conformance with the Divisional structure of the Institute, with the courses of each department of a Division being listed in a separate subsection within the pages allocated to the Division. 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 which are 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 instructor. Most courses are offered only once a year, either in the August or in the January semester. A few courses are offered in the summer term.

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

The Institute offers research-based doctoral programmes as well as both course-based and research-based Master programmes. Each course-based Master 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. At the time of joining, each course student is assigned to a Faculty Advisor, who has the responsibility of helping him/her to select courses and to monitor progress through the academic program. In order to register for a course, this student needs the approval of both the faculty advisor and the course instructor. In the first semester, the normal course load of 15-16 credits should be taken; most of these courses are core courses. From the second semester onwards, students who have done well may be permitted to take an extra course, while those who have performed badly may be required to take one course less. Students are permitted to claim an exemption from core courses on the basis of having taken them earlier. Details of how to claim such an exemption are given in the later part of this book.

The Institute follows a grading system, with continuous assessment. The course instructor first aggregates the individual marks of each student from the class tests, assignments and final examination scores. These marks are then mapped to letter grades, and only the grade is announced. The point values of grades are as follows: S – 8, A – 7, B – 6, C – 5, D - 4, F – 0. While grades S through D are passing grades, F is a failing grade.

While all the course based programmes have a specified set of core courses, research scholars are not bound to any specific courses, although they have to take a minimum number of credits as part of their Research Training Program (RTP). For Ph.D. scholars in Science, the RTP consists of 12 credits of course work. For Ph.D. scholars in Engineering, who join with ME / M Tech / M.Sc. (Engg.), the RTP requirement is a minimum of 6 credits. For BE/B Tech/M.Sc. graduates who join for Direct Ph.D., the RTP minimum requirement is 18 credits. Similar RTP requirements apply for Ph.D. candidates who upgrade their registration or transfer from the ME/M Tech or M.Sc. (Engg.) programmes of the Institute. For

the M.Sc. (Engg.) degree, the RTP consists of 12-18 credits. The Integrated Ph.D. programme has 64 credits.

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

July 2014
Bangalore-560012

Prof. Jaywant H Arakeri
Chairman
Senate Curriculum Committee

Information on the number of credits to be registered at various levels for Different programme

ME / M Tech/ M Mgt. programme (2 years duration)
Minimum number of credits for completion :64

Core courses	15-30	at 200 level
Dissertation Project	19-32	
Electives *	15-24	Balance to make up the minimum of 64 (at 200 level and above)

M Des programme (2 years duration)
minimum number of credits for competion : 64

Core courses	36	at 200 level
Electives*	12	at 200 level and above
Dissertation Project	16	

Research Traning Programme

(i) Ph D Science	**2 credits**
(ii) Ph D in Engineering Faculty with	
(a) ME / M Tech qualification	6 credits
(b) M Sc (Engg.) qualification	6 credits
(c) BE / B Tech qualification and upgrades registration	18 credits
(d) After transfer of ME / M Tech students of the institute	18 credits
(e) BE/B Tech/M Sc qualifications	18 credits

However, the final decision regarding the additional credits to be taken with regard to (c) and (d) above rests with the committee responsible for the conversion.

(iii) For M Sc (Engg.) 12-18 credits (with 3 credit maths course/s)

Integrated Ph D Programme
Minimum of 64 credits

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

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.

Prof D N Rao
Chairman, Division of
Biological Sciences

Integrated PhD (Biological Sciences)

Course Work

Core Courses: 19 credits

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

Projects: 16 Credits

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

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

DB201 (Jan 2:0)
Mathematics and Statistics for Biologists

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

Supratim Ray, N.V. Joshi, K. Sekar

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 BORGES, VIDYANAND NANJUNDIAH, AND SHYAMALA MANI

Maynard Smith, J. The Theory of Evolution, Penguin Books (1993 edition), 1958.
Bonner, J. T. Why Size Matters: From Bacteria to Blue Whales, Princeton University Press, 2007.
Sigmund, K. Games of Life, Penguin Books, 1993.
Medawar, P. Pluto's Republic (incorporating The Art of The Soluble and Induction and Intuition in Scientific Thought). Oxford
University Press, 1982.

DB 207 (AUG) 0:5
Laboratory
Basic techniques in Biochemistry, Microbiology, Biophysics, Ecological Science, Neuroscience and genetics.

Faculty

DB 212 (JAN) 0:4
Project – I

Faculty

DB 225 (AUG) 0:6
Project – II

An independent research project to be conducted in the laboratory of a faculty member in the Division of Biology, preferably in the laboratory where the PhD research will be carried out. Students will have to make a presentation, providing an overview of earlier information available in their research area, and present the proposed objectives and preliminary experiments that have been carried out.

Faculty

DB 327 (JAN) 0:6
Project- III

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

Faculty

Biochemistry

BC 201 (AUG) 2:0
Cell Biology

Cell, tissue and organ structure-function. Methods in 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.

U Tatu, D Nandi, Shikha Laloraya and Patrick D'Silva

Alberts et al., Molecular Biology of the Cell, Third edition, Garland Publ. Inc. 1994.
Darnell et al., Molecular Cell Biology, Scientific American Books, 1995.
Annual Reviews of Biochemistry.
Annual Reviews of Cell Biology.

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.

H.S.Savithri, D N Rao and U Tatu

Creighton, T.G., Proteins, W.H.Freeman, 1993.
Segel, I.H., Biochemical Calculations, Wiley, 1976.
Athel Cornish-Bowden, Fundamentals of Enzyme Kinetics, Portland Press, 2004.
Branden, Carl, and Tooze, J., Introduction to protein structure, Garland Publishing, Inc., 1999.

BC 203(AUG) 3:0
General Biochemistry

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

Patrick D' Silva, Sathees C. Raghavan, N. Ganesh and P. Rajyaguru

Stryer L., Biochemistry (4th Edn), W. H. Freeman and Company, 1995.
David L Nelson and Michael M Cox, Lehninger Principles of Biochemistry, 3rd Edn, Worth Publishers, 2000.

BC 204 (AUG) 2:0
Functional Biochemistry and Biotechnology in Health and Disease

Serious diseases : Overview of cancer, chemotherapy, cancer and apoptosis,. Artherosclorosis, hypertension and heart attack and treatment. Clotting of blood and anti thrombotic agents. **Secondary metabolites** : Terpenes, phenolic and nitrogen-containing compounds, importance of plant secondary metabolites to man. **Biotechnology :** Metabolic engineering of terpenes, alkaloids, seed oil, vitamic C, vanillin sugarcane products and sulfur compounds. Antibiotics, medicinal mushrooms. Biotic and abiotic stress physiology and strategies for enhanced production of plant and fungal secondary metabolites. Fermentation technology : submerged- and solid state-germentation, down stream processing, plant and

fungal culture, molecular farming. Plant and fungal transcription factors and their applications in biotechnology.

C Jayabaskaran

E. Newsholme and T. Leech
Functional Biochemistry in health and disease, Wiley Blackwell-2010
R.Verpoorte, A.W. Alfermann
Applications of plant metabolic engineering, Springer – 2007
M.J.Carlile, S.C. Watkindson, G.W.Gooday
The fungi (Fungi and Biotechnology) Academic Press – 2001

BC 206 (AUG) 2:0
Essentials in Immunology

Adaptive and innate immunity, 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.

D Nandi, Anjali A Karande and R Manjunath

Goldsby, R.A., Kindt, T.J., Osborne, B.A., and Kuby, J., Immunology, Fourth edition, W.H. Freeman and Company, 2000.
Roitt, I., Essential immunology, Third Edition, Blackwell Scientific Publications, 1994.
Paul, W., Fundamental Immunology, Third Edition, Raven Press, 1994.

BC 207 (Jan) 2:0
Proteomics in Practice :

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

Practicals : Two dimensional gel electrophoresis and mass spectrometry (Nano-LC-MS/MS technique)

Utpal Tatu

Reiner Westermeier, Tom Nave, Proteomics : Tools for the New Biology by Daniel C Liebler, 2002.

BC 208 (JAN) 2:0
Human Molecular Genetics

Introduction, DNA structure and genetic diseases. Cancer: classification and epidemiology, DNA damage. DNA repair: excision repair, DNA double-strand break repair, DNA repair defects and cancer. Genetic alterations in cancer: deletions, duplications, mutations and chromosomal translocations; mechanism of t(14;18) chromosomal translocation follicular lymphoma, mechanism of lymphoid translocation in T-cell leukemia. Cancer therapeutics: surgery, radiotherapy, chemotherapy, immunotherapy and hormonal therapy.

Sathees Raghavan and Arun Kumar

Erich A Nigg, Genomic instability in cancer development, Springer, 2005.
Nature Reviews Cancer

BC 209 (JAN) 2:0
Dissertation Project **(only for BC students)**

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

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

Nagasuma Chandra

Bioinformatics: From Genomes to Drugs,
Thomas Lengauer, Wiley, 2002.
Bioinformatics: Sequence and Genome Analysis, Second Edition, David Mount, Cold Spring Harbor Laboratory Press, 2001.
Drug Discovery and Evaluation: Methods in Clinical Pharmacology, Hans Georg Vogel, Jochen Maas, Alexander Gebauer, Springer, 2010.

ECOLOGICAL SCIENCES

EC 201 (JAN) 2:1
Theoretical and Mathematical Ecology (formerly Population theory)

Basic theoretical ecology, building and analyzing mathematical models of ecological systems; discrete and continuous population models; random walks, diffusion and stochastic models in ecology and evolution; Hardy-weinberg equilibrium; Drift; Game theory; Price equation, etc. elements of theoretical ecology; building and analyzing mathematical models of ecological systems; generating new ecological insights and hypotheses; discrete and continuous population models; stochastic and spatial models; random walks in ecology and evolution.

Vishwesha Guttal

Hastings, A., Population Biology: Concepts and Models, Springer, 1997.
May, R and McLean, A., Theoretical Ecology, Oxford University Press, 2007.
Strogatz, S., Nonlinear Dynamics and Chaos: with Applications to Physics, Biology, Chemistry, and Engineering, Westview, 1994.

EC 202 (AUG) 2:1
Evolutionary Ecology: Pattern and Process

History of ecology, evolution and biogeography; interactions between organisms and the environment; ecological niche; distribution of species and communities; basic population biology; interspecific interactions; community assembly; diversity, richness and abundance; biogeographic patterns across space and time; ecological and evolutionary processes (dispersal and diversification); island biogeography; meta-population biology; macroecology

Kartik Shanker

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

EC 203 (JAN) 2:0
Ecology: Principles and Applications

Earth (geology, geography, climate); ecology and society; evolutionary underpinnings to the ecology of organisms; natural selection and sexual selection; population dynamics; plant–herbivore interactions; predator–prey interactions; competition and coexistence; succession; trophic interactions and trophic cascades; ecosystems; biogeochemical cycles; global change; ecological applications; biodiversity and conservation; quantitative tools (ecological modeling and an introduction to statistics)

Sumanta Bagchi

Begon, M., C.R. Townsend, and J.L. Harper. Ecology:
From Individuals to Ecosystems, (Fourth Edition) Wiley-
Blackwell, 2005.

EC 204/ DB 209 (JAN) 2:1
Evolutionary Biology

Natural selection; units of selection; adaptation; speciation; population genetics; drift and the neutral theory; quantitative genetics; molecular phylogenetics; molecular evolution; estimating nucleotide substitutions; homologous sequences; gene trees vs. species trees; Darwinian selection at the molecular level; gene families; applications of molecular phylogenetics

Praveen Karanth

Futuyma, D. J., Evolutionary Biology (Third Edition), Sinauer Associates, 1998.
Li, W.-H. and Graur, D., Fundamentals of Molecular Evolution, Sinauer Associates, 1991.

Hartl, D. L. and Clark, A. G., Principles of Population Genetics, Sinauer Associates, 1997.

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

History and approaches, classical ethology; neuroethology: sensory processing and neural maps; learning and memory; hormones and behavior; ontogeny of behaviour; sensory ecology; sociobiology; behaviour genetics; using optimality approaches and evolutionary models to understand behavioural strategies; phylogenetic approaches to the study of behaviour; theoretical, integrative and computational approaches to studying animal behaviour.

Rohini Balakrishnan

Alcock, J., Animal Behaviour — An Evolutionary Approach (Sixth Edition), Sinauer Associates, 1998. Camhi, J.M., Neuroethology, Sinauer Associates, 1984.
Dugatkin, L.A., Principles of Animal Behaviour (Second Edition), W.W. Norton and Company, 2009.
Davies, N.B., Krebs, J.R. and Stuart, A. W. An introduction to Behavioural Ecology (Fourth Edition),Wiley-Blackwell, 2012.

EC 302 (AUG) 2:1
Plant–Animal Interactions (Ecology, Behaviour and Evolution)

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

Renee M Borges

Chittka, L. and Thompson, J. D. (Eds.), Cognitive Ecology of Pollination — Animal Behaviour and Floral Evolution. Cambridge University Press, 2001.
Herrera, C. M. and Pellmyr, O. (Eds.), Plant– Animal Interactions: An Evolutionary Approach. Blackwell Publishing, 2002.
Baluska, F., and Ninkovic, V. (Eds.), Plant Communication from an Ecological Perspective. Springer, 2010.
Schaeffer, H.M., and Ruxton, G.D. (Eds). Plant–Animal Communication. Oxford University Press, 2011.

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

Role of spatial scales in biology. (1) Single species: Fisher-Kolmogorov reaction diffusion equation and application to spread of genes and invasive species; local dispersal (diffusion) vs long-distance dispersal (fat-tailed kernels and integrodifference equations); Metapopulation dynamics. (2) Multiple-species: metacommunities; spatial patterns and self-organization (reaction diffusion and ceullar automata models). (3) Self-organization in multicellular organisms (eg. Biofilms), animal groups using individual/agent based models and (4) Evolutionary dynamics (neutral evolution and frequency-dependent selection) in space.

Vishwesha Guttal

Prerequisites: EC 201 and/or consent from the instructor.

Spatial ecology, Tilman The Role of Space in Population Dynamics and Interspecific Interactions, Edited by David Tilman & Peter Kareiva, Princeton University Press.
Pattern and Process: Spatial Simulation: Exploring Pattern and Process; David O'Sullivan George L.W. Perry, Wiley Publications.
Diffusion and ecological problems: Modern perspectives, Okubo and Levin, 2nd Edition. Springer
Evolutionary dynamics: Martik Nowak.

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; frequentist, likelihood, and Bayesian frameworks for statistical inference; statistical modeling strategies; model selection and multimodel inference; model validation

Kavita Isvaran

Hilborn, R. and Mangel, M., The Ecological Detective: Confronting Models with Data. Princeton University Press, Princeton, 1997.
Bolker, B., Ecological Models and Data in R, Princeton University Press, Princeton, 2009
Crawley, M.J., The R Book, Wiley, Chichester, 2007

EC 307 (AUG) 1:0
Advanced methods in molecular phylogenetics

Fundamentals of molecular phylogenetics; various tree building methods including distance, maximum likelihood, maximum parsimony and Bayesian approaches to tree building; historical biogeography; phylogeography; character evolution; molecular clock and time trees; DNA networks. This course is a combination of theory, paper writing and seminars.

Praveen Karanth

Prerequisite: EC204

Ne, M. and Kumar, S., Molecular Evolution and Phylogenetics, Oxford University Press, 2000.
Page, R. D. M. and Holmes, E. C., Molecular Evolution: A Phylogenetic Approach, Blackwell Science, 1998.
Hillis, D. M., Moritz, C. and Mable, B. K. (Eds.), Molecular Systematics, Sinauer Associates, 1996.

Microbiology and Cell Biology

MC 202 /RD 202 (JAN) 2:0
Eukaryotic Developmental Genetics

Logic and techniques of molecular genetic analysis. Understanding interaction networks using genetics and genomics. Illustrating the application of genetic analysis to specific developmental pathways in model eukaryotic organisms. Some examples are regulation of cell cycle, genetic and epigenetic mechanisms of cell fate determination, and signaling pathways in development.

UshaVijayraghavan, UtpalNath, and UpendraNongthomba

Current Opinion in Genetics and Development/ Cell Biology/ Plant Biology;
Trends in Genetics / Cell Biology / Biochemistry;
Principles of Development by Wolpert and co-authors;
Mechanisms in Plant Development by Leyser and Day;
Plant Physiology by Taiz and Zeiger;
Ecological Developmental Biology by Gilbert and Epel

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.

K. N. Balaji, DipshikaChakravortty, and Amit Singh

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: FundamentalsandApplications, Macmillan Press Second Edition;
Goldsby, R. A., Kindt T. J., Osborne B. A., Kuby J., Immunology, W. H. Freeman & Company, New York;
Travers, J., Shlomchik, W., Immunobiology, Garland Science publishing, New York.

MC 205 (AUG) 2:0
Host-Pathogen interactions - Bacteria, Viruses and Protozoan Parasites.

Secretion systems of bacteria: Type I, II, III, IV, V. Overview of ABC exporters and importers, plant pathogen interactions, virulence gene expression, intracellular pathogenesis. Pathogen persistence, signaling by bacterial and viral components. Innate and adaptive immunity to bacterial pathogens. Quorum sensing, biofilm formation, and its role in pathogenesis. Viral immune evasion mechanisms such as 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 MHC class I presentation of viral antigens, inhibition of host secretory pathway, prevention of phagosome acidification, antigenic variation and suppression of TH1 responses by protozoan pathogens, role of host TRIM5 family proteins in controlling HIV by mutation of viral RNA, ds-RNA and non-capped 5' end mediated recognition of pathogens by the host. Viral vectors, vaccines and drugs.

S. Vijaya and DipshikaChakravortty

David G. Russell and Siamon Gordon, Phagocyte-Pathogen Interactions: Macrophages and the Host Response to Infection, ASM Press, 2009.
Knipe, D.M., and Howley, M. (Eds), Fundamental Virology, Lippincott Williams and Wilkins, Fourth Edn. 2001.

MC 206 (AUG) 2:0
RNA Biology

Biology of RNA, with primary emphasis on eukaryotic systems. Concept of RNA world, chemical aspects of RNAses and their specificities. Types of RNA, transcription mechanisms, coupled transcription and post transcriptional processing, splicing and polyadenylation, post-transcriptional control mechanisms and mRNA stability, RNA structure and prediction, evolution of RNA sequences, RNA editing, ribozymes, RNA binding proteins, ribonucleoprotein – complexes and functions, RNA-protein recognition and interactions. Techniquesin RNA research. Non-coding RNAs: structure and function. RNA interference: siRNA and miRNAs, role of RNA in protein biosynthesis, translational control of gene expression. RNA viruses: regulation of gene expression. RNA in pathogenesis: its potential use as a drug and as a drug target.

Saumitra Das and C. Durga Rao

Gestland, R. F, Cech, T. R, & Atkins J. F., The RNA World. Cold Spring Harbor Press, New York. 3rd Edn, 2006.

MC 207 (AUG) 3:0
Molecular and Cellular Biology

DNA structure and genome organisation, chromatin remodeling, topological interconversions. Concepts and regulation of replication, transcription and translation. nucleic acid-protein interactions and regulation of gene expression, RNA editing and splicing, small RNA mediated gene regulation, DNA repair and recombination, epigenetic control of gene expression.Modern approaches to study cell biology, internal organisation of the cell, inter and intra cellular communications, vesicular transport and organelle biogenesis, protein turnover, regulation of cell cycle and cell death.

UmeshVarshney,G. Subba Rao, and Saibal Chatterjee

Lewin's GenesX, Lewin, B., Krebs, J.E., Goldstein, E.S. and Kilpatrick, S.T.
Molecular Biology of The Cell, Fifth edition, Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K. and Walter, P.

MC 208 (AUG) 3:0
Principles of Genetic Engineering

Growth and maintenance of bacterio-phages and bacterial strains containing plasmids.Enzymes used in genetic engineering.Vectors used in molecular cloning and expression of genes, promoter analyses, and gene targeting in bacterial, mammalian, human, and plant systems.DNA, RNA, and protein isolation, purification, and fractionation methods. Radioactive and nonradioactive labelling of nucleic acids and proteins, and detection. Nucleic acids hybridisationmethods. Transformation and transfection methods.Geneand cDNA cloning methods.In vitro genome packaging systems and construction of genomic DNA and cDNA libraries.Detection and characterisationmethods for genes and chromosomes.Nucleic acidssequencing methods.Methods for protein analysis, protein-nucleic acid,and protein-protein interactions.Site-specific mutagenesis*in vitro* and *in vivo*.Random mutagenesis methods *in vitro* and *in vivo*. Genome engineering methods. Polymerase chain reaction (qualitative and quantitative), methods, and applications.Antisense technology and RNA silencing techniques.DNA and Protein microarrays. Methods to generate transgenic animals. Applications of Genetic Engineering Methods in Medicine and Agriculture.

P. Ajitkumar and N. Ravi Sundaresan

J. Sambrook and D. W. Russell, Molecular Cloning: A Laboratory Manual, 3rdEdn: Vol. I, II, & III, Cold Spring Harbor Laboratory Press.
J. J. Greene and V. B. Rao. Recombinant DNA Principles and Methodologies. CRC Press.
S. B. Primrose and R. M. Twyman.Principles of Gene Manipulation and Genomics, 7thEdn, Blackwell Publishing.
Fred Ausubel and Others. Current Protocols in Molecular Biology. Wiley.
Original papers describing the principles and methods.

MC 209 (JAN) 2:0
Biological Electron Microscopy

Microscopy, different types of light microscopes, resolution, various types of electron microscopes, transmission electron microscope and scanning electron microscope, basic principle and design of electron microscope, image formation, image recording and interpretation. Processing of biological tissue for microscopy: fixation, embedding, ultramicrotomy and staining. Cryo-electron microscopy, immune-electron microscopy, negative stain technique, optical diffraction and image processing. Shadow casting and replica techniques, EM studies of DNA, binding of proteins and nucleic acids, scanning tunneling microscope and high voltage electron microscope and their use in biology.

S. S. Indi

Michael Dykstra and Laura E Reuss., Biological electron microscopy
John J Bozzola and Lonnie Dee Russell.Electron Microscopy

MC 210 (JAN) 2:0
Molecular Oncology

Immortalization, transformation, and metastasis. Genetic instability, mutation, deletion, insertion, aneuploidy, chromo-some translocation and gene amplification. Cell cycle and cancer, cell cycle checkpoints – G1 and S checkpoint, G2 and M checkpoint, cyclins and cyclin dependent kinases, CDK inhibitors – p16, p21 and p27. Oncogenes, growth factors, growth factor receptors, G protein/signal transduction, tyrosine and serine/threonine kinases and transcription factors. Tumor suppressor genes: p53, RB, BRCA1, BRCA2, APC and WT1. Mismatch repair, telomerase, DNA methylation, protein phosphorylation/dephosphorylation and degradation events. Tranformation by RNA and DNA tumor viruses (adenovirus, simian virus 40 and human papilloma virus). Onco-gene - tumor suppressor interactions, apoptosis and cancer. Cancer gene therapy.

KumaravelSomasundaram and AnnapoorniRangarajan

Robert A Weinberg. The Biology of Cancer, Garland Science Publishing, New York.

Molecular Biophysics

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

Tinoco, I., Sauer, K., Wang, J.C., Physical Chemistry, Principles and Applications in Biological Sciences, Prentice Hall, NJ, 1978.
Cantor, C.R., and Schimmel, P.R., Biophysical Chemistry, Vols. I-III, W H Freeman and Co., San Francisco, 1980.

MB 204 (AUG) 3:0
Molecular Spectroscopy and its Biological Applications

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

Siddhartha P Sarma and Mahavir Singh

Horst Friebolin, Basic One-and Two-Dimensional NMR Spectroscopy (Fourth Edition), Wiley-VCH.
Claridge, T.D., W, High Resolution NMR Techniques in Organic Chemistry, Volume 27, Second Edition (Tetrahedron Organic Chemistry) (Paperback – Dec 5, 2008).

MB 205 (AUG) 2:0
Introduction to X-ray Crystallography.

Crystal morphology and 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, chemical crystallography, structures of organic, inorganic compounds and minerals, powder diffraction.

K Suguna

Buerger, M.J., Elementary Crystallography,
Woolfson, M.M., An Introduction to X-ray Crystallography,
Stout, H., and Jenson, L.H., X-ray Structure Determination, Macmillian, 1968.

MB 206 (AUG) 3:0
Conformational and Structural aspects of biopolymers

Basic ideas on structure and conformation of simple molecules – structural features of proteins and nucleic acids, aspects of biomolecular forces. Higher order structural organization of proteins and nucleic acid.

M Bansal and N Srinivasan

Ramachandran, G.N., and Sasisekharan, V., Advances in Protein Chemistry, Vol. 23, Academic Press, p 283, 1968.
Leach, A.R., Molecular Modelling: Principles and Applications, Prentice Hall, 2001.
Schulz and Schirmer, Principles of Protein Structure, Springer Verlag, 1979.

MB 207 (AUG) 2:0
DNA-Protein interaction, Regulation of gene expression, Nanobiology

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

Dipankar Chatterji and Rahul Roy

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

MB 208 (Jan) 3:1
Theoretical and computational neuroscience

Need for and role of theory and computation in neuroscience, various scales of modelling, ion channel models, single neuron models, network and multi-scale models, models of neural plasticity. Oscillations in neural systems, central pattern generators, single neuron oscillators, oscillators as nonlinear dynamical systems, information representation, neural encoding and decoding, population codes, hierarchy and organization of sensory systems, receptive field and map modelling. Case studies, computational laboratory and projects.

Rishikesh Narayanan and S.P.Arun

Prerequisites: MB209, basic knowledge of linear algebra, probability, statistics and ordinary differential equations, and some programming knowledge.

Dayan, P., and Abbott, L.F., Theoretical Neuroscience: Computational and Mathematical Modeling of Neural Systems, The MIT press, 2005.
Koch, C., and Segev, I. (Eds), Methods in Neuronal Modeling: From Ions to Networks, The MIT press, Second Edn, 1998.
Eric De Schutter (ed.), Computational modeling methods for neuroscientists, The MIT press, 2009.
Eugene Izhikevich, Dynamical systems in neuroscience: The geometry of excitability and bursting, The MIT press, 2006.
Doya, K., Ishii, S., Pouget, A., Rao, R.P.N. (Eds), Bayesian Brain: Probabilistic Approaches to Neural Coding, The MIT press, 2007.

MB 209 (AUG) 3:1
Cellular Neurophysiology

Membrane components and structures, membrane transport, passive and active electrical properties of the membrane-ionic mechanisms of membrane and action potential, quantifying ionic hypothesis by voltage-clamp technique, Hodgkin Huxley formalism, structure-function aspects of voltage and chemically gated ionic channels, excitatory and inhibitory postsynaptic potentials, patch-clamp technique, recording and analysis of electrophysiological data, measurement of Ca concentrations in single cells, cell membrane capacitance and exocytosis, application of confocal microscopy. Synaptic plasticity, short term and long term potentiation and depression,mechanisms underlying synaptic plasticity, dendritic structure, dendritic ion channels, active properties of dendrites, dendritic spikes and backpropogating action potentials, Intrinsic plasticity, mechanisms underlying intrinsic plasticity.

S K Sikdar and Rishikesh Narayanan

Hille, B., Ionic channels of excitable membranes, Second Edin, Sinauer Associates, Massachussets.
Rudy, B., and Iverson, L.E. (Eds), Methods in Enzymology, 207, 1992.
Kandel, E.R., Schwartz, J.H., and Jessel, T.M., Essentials of Neural Science and Behaviour, Prentice Hall International, 1995.
Cowan,W. M., Sudhof, T.C, Stevens, C.F., Synapses, The John Hopkins University Press, First edition, 2003
Stuart G. Spruston N, Hausser M Dendrities, Oxford University Press, Second Edition, 2008.

MB 210 (JAN) 2:0
Peptides and Drug-Design

Organic reaction mechanisms; acids and bases; synthesis and properties of alpha, beta and gamma amino acids; conventional and contemporary ways of peptide and protein synthesis; synthesis and properties of cell-penetrating peptides; design of peptide mimics for drug-discovery, chemical genetics screening.

Jayanta Chatterjee

Norbert Sewald and Hans-Dieter Jakubke, Peptides: Chemistry and Biology, Second Edition, Wiley-VCH Verlag GmbH & Co. KGaA,2009.
Miguel Castanho and Nuno C. Santos (Eds), Peptide Drug Discovery and Development: Translational Research in Academia and Industry, Wiley-VCH Verlag GmbH & Co. KGaA,2009
Selected review articles.

MB 302 (JAN) 3:0
Macromolecular Crystallography

Review of crystallographic concepts, protein crystallization. Oscillation photography, data processing, isomorphous replacement, anomalous dispersion, multi wavelength methods, molecular replacement, refinement, model building. Quality assessment, analysis and documentation.

M R N Murthy

Denth, J., Principles of Protein X-ray Crystallography, Springer.
Duncan E. McRee, Practical protein crystallography, Elsevier.
Gale Rhodes, Crystallography made crystal clear, Wiley.
David Blow, Outline of crystallography for Biologists,. Methods in Enzymology, Vol. 276. International Tables for Crystallography, Vol. F. Oxford Univ. Press

MB 303 (JAN) 3:0
Elements of Structural Biology

Methods for determining conformations and three dimensional structures of biological macromolecules. Biophysical and biochemical methods to understand structures of proteins and protein-DNA complexes.

B Gopal

Kensal, E. Van Holde et al., Principles of Physical Biochemistry, Second Edn, Pearson Education Intl.
Cantor, C.R., and Schimmel, P.R., Biophysical Chemistry, Vols. I-III, W H Freeman and Co., San Francisco, 1980.
Research papers and reviews.

MB 305 (JAN) 3:0
Biomolecular NMR Spectroscopy

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

Siddhartha P Sarma

Cavanaugh, J., Fairbrother, W.J., Palmer, III, A.G., and Skelton, N.J., Protein NMR Spectroscopy – Principles and Practice, Academic Press, 1995.
Levitt, M., Spin Dynamics, John Wiley, 2000.
Wuthrich, K., NMR of Proteins & Nucleic Acids, John Wiley, 1986.

Molecular Reproduction, Development and Genetics

RD 201 (AUG) 2:0
Genetics

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

Mahadevan S and Arun Kumar

Strickberger, M.W., Genetics,
Suzuki, et al., An Introduction to Genetic Analysis, Prentice – Hall, India

RD 202 (JAN) 2:0
EUKARYOTIC GENE EXPRESSION

Logic and techniques of molecular genetic analysis. Understanding interaction networks using genetics and genomics. Illustrating the application of genetic analysis to specific developmental pathways in model eukaryotic organisms. Some examples are regulation of cell cycle, genetic and epigenetic mechanisms of cell fate determination and signaling pathways in development.

Upendra Nongthomba,Usha Vijayraghavan and Utpal Nath

Current Opinion in Genetics and Development/ Cell Biology/ Plant Biology; Trends in Genetics / Cell Biology / Biochemistry;
Principles of Development by Wolpert and co-authors; Mechanisms in Plant Development by Leyser and Day
Plant Physiology by Taiz and Zeiger; Ecological Developmental Biology by Gilbert and Epel

RD 203 (AUG) 2:0
Concepts in Endocrinology and Reproduction

Introduction to endocrine principles. Polypeptide and steroid hormones: their biosynthesis, structure and function. Hormones and growth factors in reproduction, receptors and signaling, physiology of mammalian reproduction from gametogenesis to embryogenesis. Molecular regulation of reproduction, hormones in contraception and infertility.

P B Seshagiri, P Kondaiah and R Medhamurthy

Jameson, J.L., De Groot, L.J., Endocrinology, Elsevier, 6th Edition 2010
Hall, J.E., Gyton and Hall Text Book of Medical Physiology, Elsevier, 12th Edition 2011

RD 204 (AUG) 2:0
Principles of Signal Transduction in Biological Systems

Principles of signal transduction, receptors, second messengers and ion channels in bacteria, yeast, Dictyostelium and mammals. Signal transduction in bacterial chemotaxis and osmoregulation. Signalling mechanisms during sexual differentiation in yeast. Sensory transduction and gene regulation in Dictyostellium. Mammalian signalling mechanisms through protein kinases, second messenger generating systems and ion channels. Signal transduction during fertilization.

Deepak K Saini

RD 205 (JAN) 2:0
Human Molecular Genetics

Human chromosomes, clinical cytogenetics, tools of human molecular genetics, organization of human genome, pattern of Mendelian inheritance, genomic imprinting, uniparental disomy and human genetic disorders, X-inactivation, genetic variation, polymorphism and mutation, gene mapping and

linkage analysis, biochemical basis of genetic diseases, genetics of cancer, genetic counseling, prenatal diagnosis.

Arun Kumar and Sathees Raghavan

Strachan and Read, Human Molecular Genetics, Garland Science, London, 2004.

RD 206 (JAN) 2:0
Molecular Oncology

Introduction to cancer biology. Immortalization, transformation, metastasis. Causes of cancer, initiators and promoters, carcinogens, tumor viruses, sporadic and familial cancer. Genetic alterations in cancer. Molecular mechanisms of carcinogenesis: cell culture and animal models. Cancer as a tissue: angiogenesis, role of stroma. Cell cycle and cancer: cell cycle checkpoints, cyclins and cyclin dependent kinases, CDK inhibitors. Oncogenes: growth factors, growth factor receptors, G protein/signal transduction, tyrosine and serine/threonine kinases and transcription factors. Tumor suppressor genes. Mismatch repair, telomerase, DNA methylation, protein phosphorylation/dephosphorylation and degradation events. Transformation by RNA and DNA tumor viruses: adenovirus, simian virus 40 and human papilloma virus, oncogene-tumor suppressor interactions. Apoptosis and cancer. Cancer and stem cells.

Annapoorni Rangarajan and Kumar Somasundaram

RD 207(AUG) 0:2
Research Course: Laboratory techniques & Analysis

Faculty

RD 208 (JAN) 0:2
Research Course II: Laboratory techniques & Analysis

Faculty

NEUROSCIENCE

NS201 (AUG) 3:0
Fundamentals of Systems and Cognitive Neuroscience

Biophysics of action potentials, brain imaging, sensation and perception, attention, motor systems and executive control, insect and animal behavior

SP Arun, Supratim Ray/Aditya Murthy(CNS)

Prerequisites: None
References: Kandel ER, Schwartz JH and Jessell TM, Principles of Neural Science, Fourth Edition, Mc-Graw Hill, 2000.

NS 202 (JAN) 3:0
Fundamentals of Molecular and Cellular Neuroscience

Molecular basis of neuronal development, neuronal transmission, synaptic organisation and its relationship to synaptic physiology, small animal behavior, learning and memory and neurological disorders.

BalajiJayaprakash, Shyamala Mani, Deepak Nair andNarenRamanan (CNS)

Prerequisites: None
References: Kandel ER, Schwartz JH and Jessell TM, Principles of Neural Science, Fourth Edition, Mc-Graw Hill, 2000.

NS 203 (JAN) 3:0
Optical Spectroscopy and Microscopy

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

BalajiJayaprakash

Prerequisites: none
Wolfgang Demtroder (2002) Laser Spectroscopy - Basic Concepts and Instrumentation, Third Edition, Springer
AmnonYariv (1989) Quantum Electronics, Third Edition, Wiley Anthony Siegman (1986) Lasers, First Edition, University Science Books

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

Sensory encoding, perception and object recognition, attention, decision making. Movement planning, cognitive control.

Supratim Ray, SP Arun and Aditya Murthy(CNS)

Prerequisites: NS 201
References: Gazzaniga MS (2009), The Cognitive Neurosciences, Fourth Edition, MIT Press.

NS 302 (JAN) 2:0
Topics in Molecular and Cellular Neuroscience

Cell fate specification, axonal path-finding, signaling in the nervous system, synaptic transmission, learning and memory and neurobiology of psychiatric and neurological disorders.

BalajiJayaprakash, Shyamala Mani, Deepak Nair and NarenRamanan (CNS)

Prerequisites: NS 202
Squire LR, Berg D, Bloom F, Sascha L, Ghosh A, Fundamental Neuroscience, Third Edition, Academic Press, 2008.

Division of Chemical Sciences

Preface

The division of Chemical Sciences comprises of the departments of Inorganic and Physical Chemistry, Materials Research Centre, NMR Research Centre, Organic Chemistry and Solid State and Structural Chemistry Unit. Students with advanced degree in Chemistry, Physics and some branches of engineering are admitted to the division's doctoral program. In addition, the division also admits B.Sc. graduates to the Integrated PhD program.

The courses offered by various departments carry a two-letter departmental code that is followed by a three digit number, the first digit of which refers to the course level. In additions, 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:

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

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 Inorganic and Physical Chemistry gives training in theoretical as well as experimental work to acquaint students with modern developments in a variety of fields in Inorganic and Physical Chemistry. The programme of instruction consists of lectures, laboratory work, seminars and special assignments.

The Materials Research Centre provides sophisticated instrumental facilities, which are essential for the fundamental and diagnostic studies of materials. The Centre offers courses in various aspects of Material Science concepts and materials characterization.

The Department of Organic Chemistry gives courses at both the fundamental and advanced levels in Organic Chemistry. The students also undergo training in advanced laboratory techniques and give seminars on topics chosen from the current literature.

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.

The NMR Research Centre offers courses and organizes workshops and symposia in the area of Nuclear Magnetic Resonance. In addition, it provides research facilities in this area to scientists from all over the country.

Prof S Ramakrishnan,
Chairman
Division of Chemical Sciences

Integrated PhD (Chemical Sciences)

Course Work

Core Courses

I Semester

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

II Semester

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

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

IV Semester
CD 241 0:10 Research Project
Six credits of optional courses in consultation with Ph. D. Supervisor.

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.

S. Natarajan/ Vasudevan

C.N.R. Rao and J. Gopalakrishnan, *New directions in solid state chemistry*
A.R. West, *Solid State Chemistry and its applications*
A.F. Wells, *Structural Inorganic Chemistry*
L. Smart and E. Moore, *Solid state chemistry : An introduction*

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

Postulates of Quantum Mechanics and introduction to operators; Exactly solvable problems Perturbational and Variational Methods, Huckel model, Many electron Atoms, Slater determinants, Hartree-Fock Variational Method for atoms; Molecular Quantum Mechanics, 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

U. Harbola

I. Levine, Quantum Chemistry
D. Griffiths, Introduction to Quantum Mechanics.
F. A. Cotton, Chemical Applications of Group Theory

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

A. G. Samuelson and P Thilagar

Shriver D.F, Atkins P.W. and Langford C.H., Inorganic Chemistry, Freeman, NY, 1990.
Cotton F.A. and Wilkinson G. Advanced Inorganic Chemistry, 5th edition, John Wiley, NY, 1987.
Huheey J.E., Inorganic Chemistry, Principles of Structure and Reactivity, Harper International, 3rd edition. 1983.

CD 213 (AUG) 3:0
Organic Chemistry – Structure and Reactivity

Kinetics and reaction mechanism, primary and secondary isotope effects, Nucleo-philic substitution, stereochemistry and conformation.

U. Maitra and S. Chandrasekhar

Carey, F. A. and Sundberg, R. J.; *Advanced Organic Chemistry, Part B*, 5th Ed., Springer, (2007)
Lowry, T. M. and Richardson, K. S.; *Mechanism and Theory in Organic Chemistry*, 3rd Ed., Addison-Wesley, (1987)
Smith, M. B. and March, J.; *March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure*, John Wiley & Sons, (2007)
Anslyn, E. V. And Dougherty, D. A.; Modern Physical Organic Chemistry, University Science Books, (2005)

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, numerical solutions 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.

N. Suryaprakash and H. S. Atreya

Thomas, G. B., Finney, R.L., Calculus and Analytical Geometry, Narosa Publishing. 1984.
Arfken, G. B. and Weber, H.J., Mathematical Methods for Physicists, Prism Indian Edition, 1995.
Keryszig, E., Advanced Engineering Mathematics, Wiley Eastern Limited, 1983.

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.

N. Jayaraman, K R Prabhu, P. Thilagar, S. Natarajan

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

Review of thermodynamics, ensembles, partition functions, averages, distributions, application to rotational and vibrational problems, specific heats of solids, phase transitions, Classical and quantum statistics, indistinguishability, dynamics: kinetics and relaxation, diffusion equation, non-equilibrium thermodynamics, light scattering. Simulations: configuration averages, central limit theorem, metropolis method, molecular dynamics, simulations of different ensembles.

Govardhan Reddy

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

CD 222 (JAN) 3:0
Material Chemistry

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

K K Nanda / Arun M Umarji / Bikramjit Basu

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

CD 223 (JAN) 3:0
Organic synthesis

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

N Jayaraman

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

CD 224 (JAN) 2:1
Computers in Chemistry

Number systems: binary, octal, decimal, hexadecimal. Computer architecture, machine language, assembly language programming, algorithms, Fortran 90 and HPF with programming examples from chemistry and other areas. Visualization. Numerical methods: interpolation, curve fitting, integration, linear algebraic systems, ordinary differential equations and matrix eigen value problems. Parallelization.

Sai G Ramesh

V. Rajaraman, Computer Programming in FORTRAN 90 and 95.
V. Rajaraman and C. Siva Ram Murthy, Parallel Computers - Architecture and Programming,
S.C. Chapra and R.P. Canal, Numerical Methods for Engineers
Errol G. Lewars, Computational Chemistry: Introduction to the Theory and Applications of Molecular Quantum Mechanics.

CD 225 (JAN) 0: 4
Physical and Analytical Chemistry Laboratory

Chemical kinetics. Langmuir adsorption, chemical analysis by potentiometric and conductometric methods, cyclic voltametry, flame photometry, electronic states by UV-Visible spectroscopy, IR

spectroscopy, solid state chemistry – synthesis of solids and chemical analysis. Thermogravimetry. X-ray diffraction, electrical and magnetic properties of solids. Vacuum techniques in preparative chemistry.

S Sampath, Aninda Bhattacharya and C Shivakumar

Vogel, A.I, Vogel's text book of quantitative chemical analysis Longman 1989.
David R Shoemaker, Carl W. Garland and Nibler J.W., Experiments in Physical Chemistry, McGraw-Hill International Edition, 1989.

CD 301 (JAN) 3:0
Two-dimensional NMR Spectroscopy

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

N Suryaprakash, S Raghothama and H S Atreya

W. R. Croasmun and R. M. K. Carlson, Two -Dimensional NMR Spectroscopy - Applications for Chemists and Biochemists, VCH, 1987.

Inorganic and Physical Chemistry

IP 203 (AUG) 3:0
Group Theory and Molecular Spectroscopy

Group theory: Symmetry elements and operations, multiplication rules, build-up of groups; classes, subgroups, homo- and isomorphisms, (matrix) representation theory, reducibility and irreducibility, the great orthogonality theorem and its applications, symmetry-adapted basis functions. **Time-dependent perturbation theory:** Basic derivations, light-matter interaction, fundamental spectroscopic definitions, shapes and widths of spectral lines. **One- and multi-electron atoms:** Spectroscopy of hydrogen-like atoms, angular momenta and selection rules of transitions, multi-electon atoms, term symbols, elementary treatment of spin-orbit coupling: L-S and J-J, selection rules, Zeeman effect, linear Stark effect. **Diatoms:** Rotations and vibrations of diatoms, anharmonic effects, selection rules for rovibrational spectra, brief treatment of electronic structure of diatoms, connection to group theory. **Polyatoms:** Euler rotations, principal axes and moments of inertia, rotational spectra of various tops; Vibrational normal modes and their symmetry properties; selection rules; electronic structure including the Franck-Condon principle (brief); concepts in Raman spectroscopy.

Sai G Ramesh

Ira Levine, Molecular Spectroscopy
Walter S. Struve -- Fundamentals of molecular spectroscopy Peter F. Bernath -- Spectra of atoms and molecules (2nd Ed.)
F. Albert Cotton -- Chemical applications of group theory

IP 211 (AUG) 3:0
Physical Chemistry – I Thermodynamics, Kinetics and Electrochemistry

Intermolecular forces: van der Waal's interactions, Lennard-Jones potentials, Stockmayer potential, hydrogen bonding. Thermodynamics: the three laws, free energies and chemical potentials, applications to electrochemistry, thermodynamic properties of liquids and solids, changes of phase. Chemical reaction dynamics: rate processes in chemistry, activated complex theory, photochemical reactions, Femtochemistry

N Munichandraiah and Atanu Bhattacharya

D.A. Mcquarrie and J.D. Simon, Physical Chemistry: A Molecular Approach, Viva Books Pvt. Ltd., New Delhi 1998

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.

M Nethaji

Taylor C.A. A nonmathematical introduction to X-ray diffraction.
Stout G. and Jensen L.H., X-ray structures determination.
Buerger M.J., X-ray Crystallography.

IP 311 (AUG) 3:0
Bio & 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.

G Mugesh

Lippard S.J. and Berg, J.M., Principles of Bioinorganic Chemistry, University Science Books, California, 1994.
Kaim, W.; Schwederski, B. Bioinorganic Chemistry: Inorganic Elements in the Chemistry of Life, Wiley, 1991
Gielen, M.; Tiekink, E. R. T. Eds. Metallotherapeutic Drugs and Metal-Based Diagnostic Agents: The Use of Metals in Medicine, Wiley, 2005

IP 312 (JAN) 3:0
Advanced Organometallic Chemistry

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

B R Jagirdar

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

IP 313 (JAN) 3:0
Electrochemical Energy Conversion and Storage

Electrochemical energy systems. Batteries, fuel cells and electrochemical capacitors. Fundamentals and applied aspects. Primary and secondary batteries. Polymer electrolyte membrane fuel cells, solid oxide fuel cells etc. Double layer- and pseudo- capacitors. Integration of electrochemical energy storage systems with other devices.

N Munichandraiah, S Sampath and P. Barpanda

B E Conway, Electrochemical Supercapacitors: Fundamentals and Applications, Kluwer, 1999.
C A Vincent and B Scrosati, Modern Batteries, Butterworth-Heinemann 1997.
T J Crompton, Battery Reference Book, Elsevier, 2000.
Sammes Nigel, Fuel Cell Technology, Springer, 2006.

IP 322 (JAN) 3:0
Polymer Chemistry

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

S Ramakrishnan

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

IP 323 (JAN) 3:0
Topics in Basic and Applied Electrochemistry

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

S Sampath

Bard A.J. and Faulkner L.R., Electrochemical methods: Principles and Applications, Wiley 1990.
Greef R., Peat R., Peter L.M., Pletcher D. and Robinson J. (Southampton Electrochemistry Group), Instrumental Methods in Electrochemistry, Ellis Harwood Ltd., 1985.
Gileadi E., Electrode Kinetics for Chemists, Chemical Engineers and Material Scientists, VCH 1993.
Vincent C.A., Modern Batteries, Edward Arnold, UK 1984.
Nozik A.J., Photoeffects at semiconductor-electrolyte interfaces, ACS, Washington 1981.

IP 324 (JAN) 3:0
Photophysics and Photochemistry:
Fundamentals and Applications

Fundamental concepts in Photophysics and photochemistry, time dependent processes (milli seconds to femtoseconds), excited states, energy transfer, relaxation phenomena, time resolved experimental methods such as absorption, fluorescence, infrared and Raman, examples with applications in chemistry and biology.

S Umapathy

N.J.Turro, Modern Molecular Photochemsitry
J.N.Demas, Excited State Lifetime Measurements

MATERIALS RESEARCH

MR 301 (AUG) 3:0
Quantum Mechanical Principles in Materials

Basics of quantum mechanics (atoms to materials). Classification of materials based on quantum mechanical principles. Classical and quantum mechanical treatment of lattice vibrations. Quantum mechanical treatment of electrical, optical and thermal properties of materials. Semiconductors, superconductors, foundations of magnetism, magnetic phenomena and their interpretation (classical and quantum mechanical approach).

Abhishek Kumar Singh

Claude Cohen-Tannoudji, Bernard Diu, Frank Laloe. Quantum Mechanics (2 vol. set), John Wiley & Sons.
Charles Kittel., Introduction to Solid State Physics, John Wiley and Sons
Neil W. Ashcroft, and David Mermin N., Solid State Physics, Brooks/Cole
Brandt and Dahmen. The Picture Book of Quantum Mechanics
Stephen Elliott, The Physics and Chemistry of Solids

MR 302 (AUG) 3:0
Crystal Defects and Properties

Descriptive crystal chemistry for ionic crystals, Pauling's rules, thermodynamics of point defects, point defects in ionic crystals, defect reactions and Kroger-Vink diagrams. Introduction to dislocations, slip, slip systems, perfect and partial dislocations. Thompson tetrahedron and dislocation reactions, planar defects, surfaces and interfaces, direct observation of defects on material. Thermal energy, heat capacity, thermal expansion, thermal conductivity. Negative expansion effects in solids. Thermal shock resistant materials. Thermoelectric effects and materials for thermal energy harvesting.

Bikramjit Basu and A M Umarji

Chiang, Y-M., Birnie IIi, D.P and Kingery W.D., Physical Ceramics – Principles for Ceramic Science and Engineering, Wiley, 1996.
Anthony R. West., Solid State Chemistry and its Applications, Wiley, 1998.
Hull, D and Bacon, D.J., Introduction to Dislocations, Butterworth-Heinemann, 2001.
Shakelford J.F.,Introduction to Materials Science and Engineering .
Rallis K.M,. Courtney T.H and Wulff J., Introduction to Materials Science and Engineering

MR 303 (AUG) 3:0
Nanomaterials Synthesis and Devices

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

Balaram Sahoo and Karuna Kar Nanda

Markov I. V., Crystal Growth for Beginners, Fundamentals of Nucleation, Crystal Growth and Epiaxy, World Scientific, 1998..
Milton Ohring., Materials Science of Thin Films, Academic Press, 2002
Surface Physics, M. Prutton, Clarendon Press, Oxford, 1975
Cao G, Nanostructures and Nanomaterials, Synthesis Properties and Applications, Imperial College Press, 2004.

MR 304 (AUG/JAN) 3:0
Characterization Techniques in Materials Science

Preparation of fine particles, growth of single crystals and thin films, thermal analysis, magnetic measurement, X-ray diffraction, SEM and TEM analyses, electrical and dielectric measurements.

Faculty Coordinators: K. B. R. Varma and Balram Sahoo

MR 305 (JAN) 3:0
Functional Dielectrics

Physical and mathematical basis of dielectric polarization, polarization in static/alternating electric fields. Conductivity and loss. piezoelectric, pyroelectric and ferroelectric concepts. Ferroic materials, primary and secondary ferroics, Optical materials. Birefringence and crystal structure, electro-optic materials and light modulators.

K. B. R. Varma

Azaroff and Brophy, Electronic processes in Materials, McGraw-Hill, New York 1963.
Von Hippel Arthur R, Dielectric Materials and Applications, MIT, Cambridge
Lines M.E. and Glass A.M., Principles and Applications of Ferroelectrics and related Materials, Clarendon Press, Oxford
Amnon Yariv ., Quantum Electronics

MR 306 (AUG/JAN) 3:0
Electron Microscopy in Materials Characterization

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

N. Ravishankar

Goldstein J.I , Romig A.D. Newbury D.E, Lyman C.E., Echlin P., Fiori C. Joy D.C. and Lifshin E.., Scanning Electron Microscopy and X-Ray Microanalysis: A Textbook for Biologists, Materials Scientists and Geologists
Williams David B and Barry Carter C.., Transmission Electron Microscopy – A Textbook for Materials Science

MR 307 (JAN) 3:0
Thin Films, Nano Materials and Devices: Science and Engineering

Thin films of functional materials including non-linear dielectrics, III-V and Nitride semiconductors. Processing, structure, and properties of materials at the nanometer length scale. Specific nanofabrication topics include epitaxy, beam lithography, self- assembly, bio-catalytic synthesis, atom optics, and scanning probe lithography. The unique size- dependent properties (electronic, ferroelectric and magnetic) and charge carrier transport in insulating and semiconducting materials and semi-conductor devices. Structure – property correlations with reference to computation, magnetic and ferroelectric storage, sensors and actuators and photo-voltaics.

S.B. Krupanidhi

"Advanced Semiconductors and Organic Nano-Techniques", edited by Morkoc H., Academic Press, 2003
Rainer Waser, Editor., Nanoelectronics and Information Technology, Wiley-VCH Verlag GmbH, Weinheim (2003)
Tester, J. W, Drake E. M, Golay M. W, Driscoll M. J., and Peters W. A.. Sustainable Energy - Choosing Among Options. Cambridge, MA: MIT Press, 2005.
Scott J.F., Ferroelectric Memories. Springer. ISBN 3540663878 (2000).

MR 308 (JAN) 2:1
Computational Modeling of Materials

Introduction to computational modeling of materials, description of atomic interaction, tight binding

approximation, Hartree-Fock, molecular orbital method, density functional theory. Applications of these methods in modeling of mechanical, electronic, magnetic, optical, and dielectric properties of materials, design principles of novel materials.

Abhishek Kumar Singh

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

MR 203 (JAN) 3:0
Introduction to Biomaterials

Basic concepts in biomaterials science. Salient properties of important material classes; concept of biocompatibility, host response, structure-property of biological cell; structure and properties of cells, protein and cellular adaptation process; various cell fate processes, cell-material interaction, Assessment of biocompatibility of biomaterials, Structure and properties of bone as well as in vivo testing and histocompatibility assessment, examples of some important metallic biomaterials, bio-ceramics and bio-composites

Bikramjit Basu

Basu B, Katti D and Kumar A , : Advanced Biomaterials: Fundamentals, Processing and Applications; John Wiley & Sons, Inc., USA, 2009.
An introduction to Materials in Medicine, Biomaterials Science (Ratner, Hoffman, Schoet and Lemons), Second Edition: Elsevier Academic Press, 2004.
Basu B and Balani K Advanced Structural Ceramics; John Wiley & Sons, Inc., USA and American Ceramic Society, 2011.

Organic Chemistry

OC 203 / CD 213(AUG) 3:0
Organic Chemistry-I

Electronic effects in organic compounds, aromaticity, frontier orbital theory, steric effects, stereochemistry, conformational analysis. Methods of deducing organic reaction mechanisms, Hammond postulate, Curtin-Hammett principle, linear free energy relationships; Hammett and Taft equations. 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.

S Chandrasekhar and Uday Maitra

Smith, M. B., March J., March's Advanced Organic Chemistry: Reactions, Mechanisms and Structure, 6th Edn. Wiley, 2007.
Carey F.A., and Sundberg R.J., Advanced Organic Chemistry, Part A. 4th ed. Plenum, 2001.
Lowry T.M. and Richardson K.S., Mechanism and Theory in Organic Chemistry, Third Edn, Addison-Wesley-Longman, 1998.
Current literature.

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.

E N Prabhakaran

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

OC 232 (JAN) 2:0
Graduate Colloquium

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

Santanu Mukherjee/K.R. Prabhu

OC 301 (AUG) 3:0
Advanced Organic Synthesis

Planning and synthesis, retrosynthetic analysis-disconnection approach, convergent synthesis, linear synthesis, protecting groups, ring forming strategy, umpolung synthesis, synthesis of natural products.

Kavirayani R Prasad

Wyatt P. and Warren S, Organic Synthesis, Strategy and Control,; Wiley 2007.
Nicolaou, K.C., Sorensen, E.J., Classics in Total Synthesis, Wiley VCH, NY 1996.
Warren S. Organic Synthesis: The Disconnection Approach, Wiley, NY, 1982.
Apsimon, Total Synthesis of Natural Products, Vol. I-IX Wiley Interscience
Currrent literature

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.

B Bagchi and S Yashonath

H.B. Callen, Thermodynamics and an Introduction to Thermo Statistics
D.A. Mcquarrie, Introduction to Statistical Mechanics
D. Chandler, Introduction to Statistical Mechanics

SS 202 (AUG) 3:0
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.

S Ramasesha

Ira Levine, Quantum Chemistry
P.W. Atkins, Molecular Quantum Mechanics
A. Szabo and N. Ostlund, Modern Quantum Chemistry

SS 205 (AUG) 3:0
Symmetry and Structure in the Solid State

Concepts of symmetry, point groups and space groups, crystal lattices. Elements of scattering theory, diffraction principles, reciprocal lattice. powder diffraction. Single crystal methods. Data collection and processing strategies, image plate and CCD detectors, synchrotron radiation usage, intensity statistics, phase problem in crystallography. Patterson and direct methods, refinement techniques, Rietveld refinement in powder diffraction. Molecular structure and crystal structure, intermolecular interactions and applications in solid state. Basics of electron density analysis from X-ray diffraction. Basics of neutron diffraction, electron diffraction, elements of electron microscopy.

T N Guru Row

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, X-ray structure determination: A practical guide,

SS 206 (JAN) 3:0
Statistical Mechanics of Liquids & Simple Systems

Microscopic aspects of liquid structure dynamics with applications to phase transitions, electrochemistry, chemical dyna7mics and biological processes.

Biman Bagchi

Chandler, Hill, McQuarrie, Widom, Material will be drawn from books on Statistical Mechanics.

SS 207 (AUG) 3:0
Non-equilibrium Statistical Mechanics:
Applications to Biological Systems

Liouville equation, projection operator technique, mode coupling theory, chemical reaction dynamics, protein folding, enzyme kinetics.

Biman Bagchi

R. Zwanzig, Non Equilbrium Statistical Mechanics, Mcquarrie, Papers and notes.

SS 301 (JAN) 2:1
Topics in Solid State Chemistry

Crystal chemistry, band theory and electronic structure of solids. Solid state spectroscopy, unified understanding of electronic, magnetic and related properties of complex materials like oxides, chalcogenides, etc. Amorphous materials, theory and practice in the preparation and characterization of solids. Preparation of solids, X-ray diffraction, Rietveld refinements, electrical conductivity, DC and AC susceptibility, differential calorimetry, XPS, IR and Raman spectra of solids.

Faculty

SS 303 (JAN) 3:0
Functional Molecular Materials: Theory and Applications

Basic concepts in conducting polymers, synthesis of conducting polymers (PANI, PTh, PPV, etc.), characterization methods of polymers: spectroscopic (NMR, PL, UV-VIS, etc.) and electrical (including impedance spectroscopy) techniques. Co-polymers, blends and composites, illustrative examples using useful polymer. Physical and chemical properties of polymers: structural correlations with glass transition temperature, crystallinity, viscoelasticity of polymers. Electronic and ionic conductivity in polymers, factors affecting conductivity, mechanisms of electronic and ionic transport (including ion association). Polymer electrochemistry; applications

Aninda J Bhattacharya and Satish A Patil

H. S. Nalwa Handbook of Organic Conductive Molecules and Polymers, John Wiley & Sons, 2nd Ed, 1997
T. A. Skotheim,Handbook of Conducting Polymers, 2nd Ed, Marcel Dekker, New York, 1998
Solid State Electrochemistry ed. P.G. Bruce (Cambridge University Press)
R.J. Young & P.A. Lovell, Introduction to Polymers, 2nd Ed, Chapman and Hall, London, 1991.
P.W. Atkins, A textbook of Physical Chemistry,
Review Papers

SS 304 (AUG) 2:0
Solar Photovoltaics: Materials and Devices

Introduction to various solar PV technologies, suitable materials for photo-voltaics, P-N junction solar cells, design of solar cells and limitation of solar cells efficiency, thin film solar cell (amorphous Silicon, CIGS and CdTe), cell structures and issues with thin film technologies. Important parameters in solar cells, current-voltage characteristic, dye sensitized solar cells, organic cells, general mechanism in organic photo-voltaic cells, critical interface and photo-physics of conjugated polymers, colloidal nanocrystal based solar cells, influence of shape and morphology engineering on solar cell efficiency.

Satish Patil

Jenny Nelson, The Physics of Solar Cell, Imperial College Press
Niyazi Serdar Sariciftci, Organic Photovoltiacs Mechanism, Materials and Devices -

CD 204 (AUG) 3:0
Chemistry of materials Solid State

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.

S. Natarajan, S. Vasudevan

C.N.R. Rao and J. Gopalakrishnan, *New directions in solid state chemistry*
A.R. West, *Solid State Chemistry and its applications*
A.F. Wells, *Structural Inorganic Chemistry*
L. Smart and E. Moore, *Solid state chemistry : An introduction*

Division of Physical and Mathematical Sciences

Preface

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

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

IN	Instrumentation and Applied Physics
MA	Mathematics
PH	Physics
AA	Astronomy & Astrophysics
HE	High Energy Physics
ES	Earth Sciences

The course numbers have the prefix of the code letter followed by the numbers. The first digit indicates the level of the course.

There are specific requirements for completing a Research Training Programme for students registering for research conferments at the Institute. For specific individual requirements, the students are advised to approach the Departmental Curriculum Committee.

The Department of Physics and the Centre for High Energy Physics offer an Integrated PhD Programme to which BSc graduates with an adequate background of Physics and Mathematics are admitted.

The Integrated PhD programme in the Mathematical Sciences is offered by the Department of Mathematics to which BSc graduates with an adequate knowledge of Mathematics are admitted.

An M Tech programme in Instrument Technology is offered in the Department of Instrumentation and Applied Physics. For all these programmes, most of the courses are offered by the faculty members of the Division, but in certain special areas, courses offered in other Divisions may also be chosen.

Prof Rahul Pandit
Chairman
Division of Physical &
Mathematical Sciences

Instrumentation and Applied Physics

M Tech Programme in Instrumentation

Duration: 2 Years 64 credits
Departmental Core: 27 credits

Hard Core: 21 credits

IN 212 3:0 Advanced Nano/Micro Systems
IN 214 2:1 Semiconductor Devices and Circuits
IN 225 3:0 Digital Signal Processing
IN 227 3:0 Control System Design
IN 244 2:1 Optical Metrology
IN 267 3:0 Bioinstrumentation and Imaging and Any Mathematics Course approved by DCC

Soft core: 6 credits to be chosen from the following courses:

IN 201 3:0 Analytical Instrumentation
IN 222 3:0 Microcontrollers and Applications
IN 224 3:0 Microelectronic Devices, Fabrication & Applications
IN 247 3:0 Principles of Tomographic Imaging
IN 251 3:0 Process Instrumentation and Control
IN 268 2:1 Microfluidic Devices and Applications.
IN 271 3:0 Cryogenic Instrumentation and Applications

Electives: The balance of 15 credits required to make up a minimum of 64 credits for completing the M Tech Programme.

IN 210 3:0 Wave propagation in periodic media
IN 221 3:0 Sensors and Measurement Techniques
IN 223 3:0 Plasma Processes
IN 226 3:0 Probability and Statistical Methods in Engineering.
IN 228 3:0 Automatic System Control Engineering
IN 232 2:1 Thin Film Deposition and Characterization
IN 234 3:0 High Vacuum Technology and Applications
IN 252 3:0 Instrumentation for Energy Conservation and Management
IN 266 3:0 Differential Geometry and Engineering Applications
IN 269 3:0 Variational Methods in Engineering
IN 301 3:0 Advanced Topics in Fluorescence Imaging

Dissertation Project
IN 299 0:19 Dissertation Project

IN 201 (JAN) 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.

S Asokan

Willard, H.W., Merritt, L.L., Dean, J.A., and Settle, F.A., Instrument Methods of Analysis Sixth Edn, East West Publishers, 1992. Strong, D.A., Holler, F.J., and Nieman, T.A., Principles of Instrumental Analysis (Fifth Edn,) Saunders, 1998. Apar Wiston, C., X Ray Methods, John Wiley and Sons, 1991.

IN 210 (AUG) 3:0
Wave propagation in periodic media

Theory of one, two and three dimensional lattices, energy velocity, energy flow, characteristics impedance, Kronig-Penny and tight binding models of crystals, wave propagation in nonlinearstructures. Transmission and reflection of electromagnetic waves on an interface, grating theory, multi-dimensional phononic and photonic crystals, materials and techniques of fabrication, nature inspired periodic structures, device applications.

Abha Misra

C. Kittel, Introduction to Solid State Physics, John Wiley & Sons 1953.A. P. French, Vibrations and WavesW. W. Norton & company 1971. Leon Brillouin, Wave Propagation in Periodic Structures, CRC Press 1997. M. Kolle, Photonic Structures Inspired by NatureSpringer 2011.

IN 212 (JAN) 3:0
Advanced Nano/Micro Systems

Fundamentals of MEMS & NEMS fabrication, Physical properties of MEMS and NEMS devices, doping, pattern generation, tools for nanoscale characterizations, CMOS based devices, fabrication of advanced sensingsystems such as image sensors used in various cameras, touch sensors, accelerometer, gyroscope, flow sensors, actuators, transducers, thermal sensor, electrostatic, piezoelectric piezoreristive sensors, chemical sensors, biological sensors, strain gauges, load cells, pressure sensors, optical sensors, signal conditioning circuits for sensors, control units etc., electrons and ions optics, single electrom tunneling, quantization of electrical conduction, electronic and photonic band gap crystals.

Abha Misra

M. J. Madou, Fundamentals of microfabrication, CRC Press 1997. H. J, Levinson, Principles of lithography, SPIE 2004. H. J. De Los Santos, Principles and Applications of Nano MEMS Physics, Springer 2008.B. Bhushan, Hand book of Nanotechnology, Springer, 2nd edition 2007.

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

Quantum Mechanics Fundamentals, Schrodinger Equation, Particle ina Box, Harmonic Oscillator, Bonding, Crystals, Winger Seitz Cell, Bragg's Law, Lattice Waves and Phonons, Reciprocal Lattice Brillouin Zones, Kronig Penny Model, Formation of Energy Bands, Metals, Semiconductors- Density of States, Fermi Function, Carrier Concentrations and Mass Action Law, Doping, Recombination andGeneration, Continuity Equation, Metal Semiconductor Junctions, PN Junctions, BJT, JFET, MESFET, MOS Capacitor, MOSFETs, Small Signal Models, Single Stage Amplifiers Basics, Organic Semiconductors, amorphous silicon, metal oxides.

Sanjiv Sambandan

Prinaciples of the Theory od Solidds, J.M. Ziman, 2nd Edition, Cambridge Univeriasty Press, Physics of Semiconductor Devices, S.M. Sze, Wiley Analysis and Design of Analog Integrated Circuits, P. P. Gray, P.J. Hurst, S. H. Lewis, Wiley.

IN 221 (JAN) 3:0
Sensors and Measurement Techniques

Sensor fundamentals, classification of sensors, general sensor characteristics, strain sensors, pressure and force sensors, vacuum sensors, radiation sensors, sensors for biomedical applications, tactile sensors, acoustic sensors, image sensors, thermal sensors. Micro sensors and actuators. Micro electro mechanical systems (MEMS): micro-fabrication and micro machining, advanced lithography techniques, diffusion & ion implantation and related aspects. Electronic interfaces & signal capture and modulation, large area electronic sensors.

K Rajanna and S Sanjiv

Norton, H.N., Handbook of Transducers, Prentice Hall, 1989.Gardner, J. W., Microsensors: Principles and Applications, John Wiley, 1994.Ristic, L. R. (ed.), Sensor Technology and Devices, Artech House Publishers,1994.

Àpar Street, R. A. Technology and Applications of Amorphous Silicon, Springer,1999. Current Literature on Sensors and Actuators

IN 222 (JAN) 3:0
Microcontrollers and Applications

Architecture of Microcontrollers and hardware interfacing techniques. Introduction to Integrated development environment for application software development. A/D – D/A interfaces. Stepper and DC Motor controls. Finite state Machine Models for applications. Case studies of applications controlled via local keyboard or by using serial Interfaces. Use of I2C bus in applications.

S Ramgopal

Ayala, The 8051 Microcontroller, Third Edn, Thomson, 2007.
Mazidi, M.A., Mazidi, J.G., and Mckinlay, R.D., The 8-51 Microcontroller and Embedded Systems using Assembly and C,Second Edn, Pearson Education.

IN 223 (AUG) 3:0
Plasma Processes

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

G Mohan Rao

Chapman, B.N., Glow Discharge Processes, John Wiely and Sons, 1979.
Vossen, J.L., and Kern, W. (Eds), Thin Film Processes, Academic Press, 1979.
Cuomo, J.J., Rossnagel, S.M., and Kauffman, H.R. (Eds), Handbook of Ion beam Processing Techniques, Noyes Publications, 1989.

IN 224 (JAN) 3:0
Microelectronic Devices Fabrication and Applications

Semiconductors, growth techniques and properties, thin film phenomena, PVD and CVD techniques, ion implantation and rapid thermal annealing, lithography and ion beam etching, ceramics, glasses and plastics in microelectronics, packaging techniques, microelectronic devices.

G Mohan Rao

Sze, S.M., Physics of Semiconductor Devices, Wiley Eastern, 1993.
Campbell, S.A., The Science and Engineering of Microelectronic Fabrication, Oxford University Press, 1996.

IN 225 (AUG) 3:0
Digital Signal Processing

Signal theory, random processes and sequences. Introduction to sampling theorem. Z-transforms, discrete Fourier transforms, fast Fourier transforms and its applications, windowing techniques, convolution and correlation-signal detection techniques – digital filters, moving average filter, FIR and IIR filters, quantization and rounding problems in digital filters. Spectrum analysis and estimation techniques. DSP system concept and design. Introduction to DSP hardware. Algorithms and instrumentation applications.

R M Vasu and P C Mathias

Proakis, J.G., and Monolokis, D.G., Digital Signal Processing Principles, Algorithms and Applications, Prentice Hall, 1995.
Oppenheim, A.V., and Schafer, R.W., Digital Signal Processing, Prentice Hall, 1975.

IN 226 (AUG) 3:0
Probability and Statistical Methods in Engineering.

Introduction, elements of probability theory, counting rules and probabilities, random variables, escriptive properties of distribution, discrete case, continuous distributions, normal distribution, transformation of variables, Monte Carlo method, Markovchains. Statistical inference-estimation,

hypothesis testing, t-distribution, chi-distribution, F-distribution, simple regression and correlation DOE-geometric approach, factorial design, mixer design.

M Chandran

David J. Saville, statistical Methods : The geometric approach Springer. 1991
Meyer, P.L., Introductory Probability and Statistical Applications, Amerind Publishing Co., 1975.
Chao, L.L., Statistics – Methods and Analysis, McGraw Hill, 1974.

IN 227 (JAN) 3:0
Control Systems Design

Dynamics of linear systems, Laplace transforms, analysis of feedback control systems using Nyquist plots, Bode plots and Root Locus, design of control systems in single-degree of-freedom configuration using direct design, proportional-integral-derivative control, lead-lag ompensation, design of control systems in two-degree of-freedom configuration to achieve robustness, ntitative feedback theory control of non-minimum phase systems, Bode sensitivity integrals, use of discribing functions to analyze and compensate nonlinearities.

G R Jayanth

Horowitz I.M., Synthesis of Feedback Systems, Academic Press, 1963.
Goodwin G. C., Graebe S. E.,. Salgado M. E, Control System Design, PHI Learning, 2001.
Sidi, marcel, design of Robust Control Systems, Kriegar, 2001.

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

Digital interfacing, A/D conversion by 8 bit, 12 bit and 16 bit, system calibration, compensation. Application of proportional control and PID control to systems and comparison, case studies. Stability analysis and performance modeling. Advantages of microcomputer based industrial process control systems. Remote control methods. Introduction of fuzzy logic and Application. Linux infrared remote control.

T K Mondal

Hall, D.V., Microprocessors and interfacing, McGraw Hill, 1986.
John Van De Vegte, Feedback control system, Prentice Hall Intl, Inc.
Terano, T., Asai, K., Sugeno, M. (Eds), (Translated by Charles Aschmann), Applied Fuzzy Systems, Professional, Boston, 1994).

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, data conversion (ADC/DAC) circuits, CAD for analog circuits. Digital circuits: interfacing, PC fundamentals, role of PC in instrumentation, parallel port, serial RS232, CAN, 12C, SPI, protocols. Logic family characteristics: TTL 12L, CMOS, ECL, Low voltage logic. Basic introduction to microcontrollers and programmabel logic. RF circuits: basic transmission line theory, impedance matching smith chart, stability of RF amplifiers, VCOs, mixers, PLLS. Measurement and characterization of noice.

Atanu K Mohanty

Horowitz, P., and Hill, W., Art of Electronics. Second Edn, Cambridge Univ. Press, 1980.
Ryder, J.D., Networks, lines and Fields, Second Edn, prentice Hall of India, 1955.
Millman, J., and Halkias, C.C., Integrated Electronics, Mcgraw Hill, Auckland, 1972.

IN 232 (AUG) 2:1
Thin Film Deposition and Characterization

Deposition techniques: electroplating, CVD, Solgel, resistive, electron beam, flash and laser evaporation, DC and RF diode, triode and magnetron sputtering. Ion plating, ion beam

deposition,plasma CVD and MBE. Deposition systems and accessories – design and fabrication details of electron beam guns, ion sources. Film thickness measurement and monitoring techniques. Film characterization techniques: X-rays and electron beam techniques for structure and composition, instrumentation for measuring electrical, optical and electromechanical properties of films.

K Rajanna

Chopra, K.L., Thin Film Phenomena, Rober G. Krieger Publishing, NY, 1979.
Maissel, L., and Glong, R., Hand Book of Thin Film Technology, McGraw Hill, London, 1970.
Àpar Vassen, J.L., and Kem, W., Thin Film Process, Academic Press, NY, 1978.

IN 234 (AUG) 3:0
High Vacuum Technology and Applications

Kinetic theory of gases in closed systems, production and measurement of high vacuum, materials for vacuum environment, vacuum system design and fabrication, leak detection. Applications of high vacuum in thin film technology, metallurgy and space technology. Concepts of ultra high vacuum techniques.

G Mohan Rao

Roth, A., Vacuum technology, Elsevier Science, 1996.
O'Hanlon, I., A User Guide to Vacuum Technology, Wiley-Interscience, 2003.
Lafferty, J.M., Foundations of Vacuum Science and Technology, John Wiley and Sons, 1998.

IN 244 (JAN) 2:1
Optical Metrology

Fundamentals of Optics: Ray Optics, Wave Propagation, Diffraction,Refraction, Intereference, Polarization, Coherence, Fourier Optics,ATF, OTF and MTF for Imaging Systems.

Dimensional Metrology: Pinhole Camera Model, Camera Calibration,Laser Triangulation, Structured Illumination Techniques, FringeAnalysis, Phase Unwrapping, System Calibration Techniques.Various Interferometric Techniques such as Michelson, Mach-Zehnder,
Fabry-Pérot, Holographic, Speckle, Moiré, VISAR and Common PathInterferometry.

Metrology with Optical Microscopy: Basics of Microscopy, 2-D and 3-Dmeasurements, Optical Sectioning, Super-resolution, Surface Profilingand Quantitative Phase Imaging.

This course also aims at providing hands-on experience for importantrepresentative experimental techniques such as MichelsonInterferometry, 4-f System, digital holography, fringe projection profilometry and quantitative phase imaging in microscopy.

Sai Siva Gorthi

Introduction to Fourier Optics by Joseph W.Goodman, Roberts and Company, 3rd edition,2005
Fundamentals of Photonics by B.E.A. Saleh and M.C.Teich,Wily 2nd edition,2013
Optical Metrolog by Kjell J.Gasvik,Wily 3rd edition, 2002
Quantitative Phase Imaging of Cells and Tissues by Gabriel Popescue,M.C.Graw Hill Professional 1st edition, 2011.

IN 247 (JAN) 3:0
Principles of Tomographic Imaging

Radon transform and its properties, inversion methods using FBP, ART and its variations for both parallel and fan beam illumination. Optical tomography. Refraction correction strategies. Diffraction correction in optical tomography, data gathering for optical tomography, wave-front estimation techniques, phase unwrapping. Experimental aspects and applications.

R M Vasu

Deans, S.R., The Radon Transform and some of its Applications, John Wiley, 1993.

Herrman, G.T., Image Reconstructions from Projection: The Fundamentals of Computerized Tomography, Academic Press,1980.
Kak A.C., and Slaney, M., Principles of Computerized Tomographic Imaging, IEEE Press, 1988.

IN 251 (JAN) 3:0
Process Instrumentation and Control

Measurement of process and system variables, thermal, mechanical and optical sensors, analog and digital signal conditioning, principles of automatic control, discrete state process control, control hardware, actuators, relays, switches and valves, analog and digital controllers, control loop characteristics and analysis, process tuning, PLCs in process control, distributed control systems, smart sensors. Application of MEMS in process industry.

J Nagaraju

Johnson, C., Process Control Instrumentation Technology, Prentice Hall of India, 1996.
Doeblin, E.O., Measurement Systems – Application and Design, McGraw Hall, 1975.
Ogata, K., Modern Control Engineering, Prentice Hall of India, 1994.

IN 252 (AUG) 3:0
Instrumentation for Energy Conservation and Management

Principles and techniques of energy audit and management, energy conservation methods, evaluation and measurement techniques, heat flux meters, BTU meters suitable for heat exchangers andgaseous fuels calorimeters. Instrumentation for renewable energy systems (solar thermal, photovoltaic and wind energy). Energy management devices, electromechanical devices, micro controller based systems.

J Nagaraju

Reay, D.A., Industrial Energy Conservation, Pergamon Press, 1977.
Hodge, B.K., Analysis and Design of Energy Systems, Prentice Hall, 1988.
Liptak, B.G. (ed.), Instrument Engineers Handbook, Chinton Book Company, 1982.

IN 266 (JAN) 3:0
Differential Geometry and Engineering Applications

Fundamentals of linear algebra, linear structure, parametric representation, change of variables, linear forms, bilinear forms, Tensors, Gauss, Green, Stokes theorem, differential geometry, differential forms. Lie derivative, Some application in FEM, and some case studies.

M Chandran

Anton, H., and Rorres, C., Elementary Linear Algebra, Application version, John Wiley and Sons, 1994.
Munkres, J.R., Analysis on manifolds, Addison Wesley, 1991.
Wendell Flaming. Functions of Several variables. – Springer 1977.

IN 267 (AUG) 3:0
Fluorescence Microscopy and Imaging

Light Sources, Monochromators, Optical Filters, Photomultiplier tubes, polarizers, Beer-Lambart Law, Paraxial ray Optics and System Designing, Wave Optics, electromagnetic theory, fluorescence microscopy systems, molecular physics, photo-physics and Stern-Volmer equation, Jablonski diagram, emission spectra, fluorescence lifetime and quantum yield, time-domain lifetime measurements, fluorescence correlation spectroscopy, total internal reflection fluorescence microscopy, electric field effects, point spread function, single-and multi-photon fluorescence microscopy, advanced super resolution microscopy, aperture engineering techniques, 3D image reconstruction, Markov random field, maximum likelihood algorithm, Bayes theorem.
Partha P. Mondal.

Prerequisites: Knowledge of C and MATLAB Programming.
James Pawley, Handbook of Biological Confocal Microscopy, Springer, Springer Science + Business Media, 3rd Edition, 2006.
J. R. Lakowicz, Principles of Fluorescence Spectroscopy, 3rd Edition, Springer, 2006.
M. Born and E. Wolf, Principles of Optics, 7th Edition, Cambridge University Press, 2001.
Alberto Diaspro, Nanoscopy and Multidimensional Optical Fluorescence Microscopy, CRC, 1st Edition, 2010.
C. Gonzalez and R. E. Woods, Digital Image Processing, 3rd Edition.

IN 268 (AUG) 2:1
Microfluidic Devices and Applications

Basic principles in microfluidics, design principles for microfluidic devices, device fabricationProcedures, (such as optical lithography and soft lithography), components of microfluidic devices (micro-pump, mixers, lenses, valves, heaters, sensors, etc.,) utility of microfluidic devices in various biological, chemical and optical sensing applications, opto-fluidics, Inertial-microfluidics, droplet-microfluidics, microfluidics based-flow cytometry. This course also provides hands on-experience in the design, fabrication and characterization of Lab-on-achips or point-of care testing devices.

Sai Siva Gorthi

Introduction to Microfluidics by Patric tabeling. (2005)
Fundamentals and Applications of Micro-fluidicsBy Nam-Trung nguyen and Stev(2008) Wereley (2006)
Biological Applications of Microfluidics edited by Frank A. Gomez
Theoretical Microfluidics byHenrik Bruus (2007)

IN 269 (AUG) 3:0
Variational Methods in Engineering

Fundamentals of linear algebra, fundamentals of real analysis, functional, Gateux variations, Lagrange multiplier and applications, inequality constraints, Optimal control theory, linear quadratic regulator, Ritz method, Galerkin method, Least square method, steepest descent, application of variational methods in ODE, PDE, some case studies.

M Chandran and G R Jayanth

Prerequisite: MATLAB and MAPLE (Laptop is essential)
Donald R Smith,Variational Methods in Optimization, Prentice Hall, 1974.
Karel Rektorys, Variational methods in Mathematics, Science and Engineering, D. Reidel Publishing Co. 1975.

IN 271 (JAN) 3:0
Cryogenic Instrumentation and Applications

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

Randall F. Barron, Cryogenic Systems, Second Edition, Oxford University Press, 1985.
Thomas M. Flynn, Cryogenic Engineering, Marcel Dekker Inc, 1997.
J. G. Weisend II, Handbook of Cryogenic Engineering, Taylor & Francis, 1998.

IN 301 (JAN) 3:0
Advanced Topics in Fluorescence Imaging.

Electric field at the geometrical focus of a fluorescence imaging system. Photophysics, Super-resolution Fluorescence Imaging, PSF Engineering for super-resolution microscopy, fluorescencecorrelation spectroscopy. Multidimensional Image reconstruction for Fluorescence Microscopy.

Partha P Mondal

Prerequisites: Optics, C and MATLAB programming, Molecular Physics, Bioimaging, Bioinstrumentation.

Reviews, research articles and conference proceedings.

IN 299 0:19
Dissertation Project

The dissertation project aims at providing the candidates with an opportunity to design and build complete systems or sub-systems in an area where they would like to acquire specialized skills. A report is to be submitted at the culmination of the project. The project will be evaluated on the basis of (i) physical inspection of the project (ii) project report and (iii) oral examination.

Faculty

MATHEMATICS

Course No.	Credits	Course title
Core Courses (these are compulsory)		
MA 212	3:0	Algebra
MA 213	3:0	Representation Theory of Finite Groups
MA 219	3:0	Linear Algebra
MA 221	3:0	Real Analysis
MA 222	3:0	Measure Theory
MA 223	3:0	Functional Analysis
MA 224	3:0	Complex Analysis
MA 229	3:0	Calculus on Manifolds
MA 231	3:0	Topology
MA 232	3:0	Introduction to Algebraic Topology
MA 241	3:0	Ordinary Diff. Equations
MA 242	3:0	Partial Diff. Eqns.
MA 261	3:0	Probability Models
Soft Core		
MA 315	3:0	Galois Theory
MA 361	3:0	Probability Theory
Project :		
MA 201	7.0	Project
Elective Courses		
MA 210	3:0	Logic, Types and Spaces
MA 226	3:0	Complex Analysis II
MA 312	3:0	Commutative Algebra
MA 316	3:0	Homological Algebra
MA 317	3:0	Number Theory
MA 318	3:0	Combinatorics
MA 325	3:0	Operator Theory II
MA 327	3:0	Topics in Analysis
MA 329	3:0	Topics in Several Complex Variables
MA 338	3:0	Differentiable Manifolds and Lie Groups
MA 347	3:0	PDE and Finite Element Method

MA 212 (AUG) 3:0
Algebra

Groups : Review of Groups, Subgroups, Homomorphisms, Normal subgroups, Quotient groups, Isomorphism theorems. Group actions and its applications, Sylow theorems. Structure of finitely generated abelian groups, Free groups.
Rings : Review of rings, Homomorphisms, Ideals and isomorphism theorems. Prime ideals and maximal ideals. Chinese remainder theorem. Euclidean domains, Principal ideal domains, Unique factorization domains. Factorization in polynomial rings.
Modules : Modules, Homomorphisms and exact sequences. Free modules. Hom and tensor products. Structure theorem for modules over PIDs.

ABHISHEK BANERJEE

Artin, M., *Algebra*, Prentice-Hall of India, 1994.
Dummit, D.S. and Foote, R.M., *Abstract Algebra,* John Wiley & Sons, 2001.
Hungerford, T.W., *Algebra*, Springer (India), 2004.
Herstein, I.N., *Topics in Algebra*, John Wiley & Sons, 1995.

MA 219 (AUG) 3:0
Linear Algebra

Vector spaces : Basis and dimension, Direct sums.
Determinants: Theory of determinants, Cramer's rule.
Linear transformations: Rank-nullity theorem, Algebra of linear transformations, Dual spaces. Linear operators, Eigenvalues and eigenvectors, Characteristic polynomial, Cayley-Hamilton theorem, Minimal polynomial, Algebraic and geometric multiplicities, Diagonalization, Jordan canonical Form.
Symmetry: Group of motions of the plane, Discrete groups of motion, Finite groups of SO(3).
Bilinear forms: Symmetric, skew symmetric and Hermitian forms, Sylvester's law of inertia, Spectral theorem for the Hermitian and normal operators on finite dimensional vector spaces.
Linear groups: Classical linear groups, SU_2 and $SL_2(\mathbf{R})$.

POOJA SINGLA

Artin, M., *Algebra*, Prentice Hall of India, 1994.
Herstein, I.N., *Topics in Algebra*, Vikas Publications, 1972.
Strang, G., *Linear Algebra and its Applications,* Third Edition, Saunders, 1988.
Halmos, P., *Finite dimensioinal Vector spaces*, Springer-Verlag (UTM), 1987.
Hoffman, K. and Kunze, R., *Linear Algebra,* 2nd Edition, Prentice Hall.

MA 221 (AUG) 3:0
Real Analysis

Review of Real and Complex numbers systems, Topology of R, Continuity and differentiability, Mean value theorem, Intermediate value theorem, Implicit function theorem, Inverse function theorem, Sequence and series of functions, Uniform convergence, Riemann-Stieltjes integral.

THIRUPATHI GUDI

RUDIN, W., *PRINCIPLES OF MATHEMATICAL ANALYSIS*, MCGRAW-HILL, 1985.
APOSTOL, T. M., *MATHEMATICAL ANALYSIS*, NAROSA, 1987.
GOLDBERG, R.R., *METHODS IN REAL ANALYSIS,* OXFORD & IBH, 1970.

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 upto the spectral theorem for compact, self – adjoint operators.

S. THANGAVELU

Goffman, C. and Pedrick, G., *First Course in Functional Analysis*, Prentice-Hall of India, 1995.
Conway, J. B., *A Course in Functional Analysis*, Springer, 1990.
Taylor, A. E., *Introduction to Functional Analysis,* Wiley International Edition, 1958.
Bachman, G., and Narici, L., *Functional Analysis,* Academic Press, 1966.
Rudin, W., *Functional Analysis,* 2nd Edition, Tata McGraw-Hill, 2006.
Yosida, K., *Functional Analysis,* 4th Edition, Narosa Publishing House, 1974.

MA 226 (AUG) 3:0
Complex Analysis II

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

JAIKRISHNAN J. / GAUTAM BHARALI

Narasimhan, R., *Complex Analysis in One Variable,* 1st ed. or 2nd ed. (with Y. Nievergelt), Birkhauser (2nd ed. is available in Indian reprint, 2004)
Greene, R.E. and Krantz, S.G., *Functions Theory of One Complex Variable*, 2nd ed., AMS 2002 (available in Indian reprint, 2009, 2011)

MA 231 (AUG) 3:0
Topology

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

BASUDEB DATTA

Armstrong, M. A., *Basic Topology*, Springer (India), 2004.
Janich, K., *Topology,* Springer-Verlag (UTM), 1984.
Munkres, K. R., *Topology (a first course),* Prentice Hall of India, 1983.
Viro, O. Ya., Ivanov, O. A., Netsvetaev, N. and Khariamov, 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 Complexes, Simplicial and Singular-homology – Definitions, Properties and Applications.

SIDDHARTHA GADGIL

Armstrong, M. A., *Basic Topology*, Springer (India), 2004.
Hatcher, A., *Algebraic Topology,* Cambridge Univ. Press, 2002.
Kosniowski, C., *A First Course in Algebraic Topology,* Cambridge Univ. Press, 1980.

MA 242 (AUG) 3:0
Partial Differential Equations

First order partial differential equation and Hamilton-Jacobi equations ; Cauchy problem and classification of second order equations, Holmgren's uniqueness theorem; Laplace equation; Diffusion equation ; Wave equation; Some methods of solutions, Variable separable method.

M. K. GHOSH

John, F., *Partial Differential Equations*, Springer (International Students Edition), 1971.
Evans, L. C., *Partial Differential Equations,*
AMS, 1998.

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.

M. K. GHOSH

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

MA 316 (AUG) 3:0
Introduction to Homological Algebra

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

UMESH V. DUBEY

Cartan and Eilenberg, *Homological Algebra*.
Weibel, *Introduction to Homological Algebra*.
Rotman, *Introduction to Homological Algebra*.

MA 317 (AUG) 3:0
Introduction to Number Theory

Part I: Factorization and prime numbers, Congruences, Primitive roots, Quadratic residues, Continued fractions, Irrational numbers, Approximation of irrationals by rationals, Some Diophantine equations, Algebraic and Transcendental numbers.

Part II: Arithmetical functions, Averages of Arithmetical functions, Summation formulas, Distribution of primes-I (elementary estimates), Dirichlet series and Euler products, Introduction to the Riemann zeta function.

SOUMYA DAS

Hardy, G.H. and Wright, E.M., *An Introduction to the Theory of Numbers* (6th ed, Oxford University Press, (2008).
Ireland, K. and Rosen, M., *A Classical Introduction to Modern Number Theory,* GTM 84, Springer, (1990).
Apostol, T.M., *Introduction to Analytic number theory,* UTM, Springer, (1976).
Niven I., Zuckerman, H.S. and Montgomery, H.L., *An introduction to the theory of Numbers* (Fifth ed.), John Wiley and Sons, Inc., (1991).

MA 325 (AUG) 3:0
Operator Theory II

Sz.-Nagy, Foias theory : Dilation of contractions on a Hilbert space, minimal isometric dilation, unitary dilation. Von Neumann ?s inequality. Ando?s theorem: simultaneous dilation of a pair of commuting contractions. Parrott?s example of a triple of contractions which cannot be dilated simultaneously. Creation operators on the full Fock space and the symmetric Fock space.

Operators spaces, Completely positive and completely bounded maps. Endomorphisms. Towards dilation of completely positive maps. Unbounded operators: Basic theory of unbounded self-adjoint operators.

GADADHAR MISRA

Conway, J.B., *A course in Functional Analysis,* Springer, 1985.
Paulson, V., *Completely Bounded Maps and Dilations,* Pitman Research Notes, 1986.

MA 327 (AUG) 3:0
Topics in Analysis

In this course we begin by stating many wonderful theorems in analysis and proceed to prove them one by one. In contrast to usual courses (where we learn techniques and see results as `applications' of those techniques), we take a somewhat experimental approach in stating the results and then exploring the techniques to prove them. The theorems themselves have the common feature that the statements are easy to understand but the proofs are non-trivial and instructive. And the techniques involve analysis.

We intend to cover a subset of the following theorems: isoperimetric inequality, infinitude of primes in arithmetic progressions, Weyl's equidistribution theorem on the circle, Shannon's source coding theorem, uncertainty principles including Heisenberg's, Wigner's law for eigenvalues of a random matrix, Picard's theorem on the range of an entire function, principal component analysis to reduce dimensionality of data...

Prerequisites: Real analysis, complex analysis, basic probability, linear algebra, groups. It would help to know or to concurrently take a course in measure theory and/or functional analysis.

MANJUNATH KRISHNAPUR

Korner, I. T. W., *Fourier Analysis*, Cambridge University Press, 1 ed., 1988
Rudin, W., *Real and Complex Analysis*, Tata McGraw Hill Education, 3rd ed., 2007
Thangavelu, S., *An Introduction to the Uncertainty Principle*, Birkhauser, 2003
Serre, J. P., *A Course in Arithmetic*, Springer-Verlag, 1973
Robert Ash., *Information* Theory, Dover Special Priced Titles, 2008

MA 329 (AUG) 3:0
Topics in Several Complex Variables

In this topics course, we would like to try out the notion of approaching the essential concepts in several complex variables with the eventual aim of studying some topics in multi-variable complex dynamics.

Thus, the course will begin with a complete and rigorous introduction to holomorphic functions in several variables and their properties. This will pave the way to motivating and studying the concept of plurisubharmonicity.

Finally, we shall study some complex dynamics i.e., the dynamics of the iterations of a holomorphic map in several variables using the tools developed.

Prerequisites : MA 224 (i.e., the first course in Complex Analysis) and, **preferably**, MA 324 (Topics in Complex Analysis in One Variable). Students who have not taken MA 324 but are highly interested in this course are encouraged to speak to the instructor.

GAUTAM BHARALI

Hormander, L., *An Introduction to Complex Analysis in Several Variables* (3rd ed.), North-Holland Publishing Co. Amsterdam, 1990.

MA 338 (AUG) 3:0
Differentiable Manifolds and Lie Groups

Differentiable manifolds : Differentiable manifolds, differentiable maps and tangent spaces; regular values and Sard's theorem; submersions and immersions; vector fields and flows; the exponential map; Frobenius's Theorem; Lie groups, Lie algebras and the exponential map; homogeneous spaces; tensors and differential forms; the Lie derivative; orientable manifolds; integration on manifolds and Stokes's Theorem.
Riemannian Geometry : Riemannian metrics, the Levi−Civita connection; curvature and parallel transport.

HARISH SESHADRI

Kumaresan, S., *A Course in Differential Geometry and Lie Groups*, Texts and Readings in Mathematics, 22, Hindustan book Agency, 2002
Warner, F., *Foundations of Differentiable Manifolds and Lie Groups*, Graduate Texts in Mathematics, 94, Springer-Verlag, 1983

MA 210 (JAN) 3:0
Logic, Types and Spaces

This course is an introduction to logic and foundations from both a modern point of view (based on type theory and its relations to topology) as well as in the traditional formulation based on first-order logic.

Topics : Basic type theory : terms and types, function types, dependent types, inductive types.
First order logic: First order languages, deduction and truth, Models, Godel's completeness and compactness theorems.

Godel's incompleteness theorem

Homotopy Type Theory : Propositions as types, the identity type family, topological view of the identity type, foundations of homotopy type theory.

Most of the material will be developed using the dependently typed language / proof assistant Agda. Connections with programming in functional language will be explored.

SIDDHARTHA GADGIL

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

Homotopy Type Theory: Univalent Foundations of Mathematics, Institute for Adv. Studies, Princeton 2013, available at http://homotopypetheory.org/book/
Manin, Yu., I., *A Course in Mathematical Logic for Mathematicians*, second Edition, Graduate Texts in Mathematics, Springer-Verlag, 2010.
Srivastava, S. M., *A Course on Mathematical Logic,* Universitext, Springer-Verlag, 2008.

MA 213 (JAN) 3:0
Representation Theory of Finite Groups

Representation theory: Representations of finite groups, irreducible representations, complete reducibility, Schur's lemma, characters, orthogonality, class functions, regular representations and induced representations, the group algebra.
Linear groups: Representations of the group SU_2.

POOJA SINGLA

Artin, M., *Algebra*, Prentice Hall of India, 1994.
Fulton W., and Harris, J., *Representation Theory*, Springer-Verlag, 1991.
Serre, J. P., *Linear Representations of Finite Groups*, Springer-Verlag, 1977.

MA 222 (JAN) 3:0
Measure Theory

Construction of Lebesgue measure, Measurable functions, Lebesgue integration, Abstract measure and abstract integration, Monotone convergence theorem, Dominated convergence theorem, Fatou's lemma, Comparison of Riemann integration and Lebesgue integration, Product sigma algebras, Product measures, Sections of measurable functions, Fubini's theorem, Signed measures and Radon-Nikodym theorem, L^p spaces, characterization of continuous linear functionals on L^p spaces, Change of variables, Complex measures, Riesz representation theorem.

HARISH SESHADRI

Royden, H. L., *Real Analysis*, Macmillan, 1988.
Folland, G.B., *Real Analysis: Modern Techniques and their Applications,* 2nd edition, Wiley.
Hewitt, E. and Stromberg, K., *Real and Abstract Analysis,* Springer, 1969.

MA 224 (JAN) 3:0
Complex Analysis

Complex numbers, Analytic functions, Cauchy's integral theorem, integral formula, Power series, Liouville's theorem, Mean-value and maximum-modulus theorem, Morera's theorem, Schwartz reflection principle, Isolated singularities, Residue theorem, Contour integration, Möbius transformations, Conformal mappings, The Riemann mapping theorem, Analytic continuation, Schwarz lemma.

S. THANGAVELU

Ahlfors, L.V., *Complex Analysis*, McGraw-Hill, 1979.
Conway, J.B., *Functions of a Complex Variable,* Springer-Verlag, 1978.

MA 229 (JAN) 3:0
Calculus on Manifolds

Functions of several variables, Directional derivatives and continuity, total derivative, mean value theorem for differentiable functions, Taylor's formula.
The inverse function and implicit function theorems, extreme of functions of several variables and Lagrange multipliers. Sard's theorem.
Integration on Euclidean spaces, Fubini's theorem, the change of variables formula and partitions of unity.

Manifolds : definitions and examples. Vector fields and differential forms on manifolds. Stokes' theorem.

A. K. NANDAKUMARAN

Spivak, M., *Calculus on Manifolds*, W.A. Benjamin Co., 1965.
Apostol, T.M., *Mathematical Analysis*, Narosa Pub. House, Indian Ed.
Munkres, J., *Analysis on Manifolds*.
Rudin, W., *Principles of Mathematical Analysis,* Mc-Graw their International Ed.

MA 241 (JAN) 3:0
Ordinary Differential Equations

Basic concepts: Introduction and examples through physical models, First and second order equations, Concepts of general and particular solutions, linear and nonlinear systems, independence and some methods.
Existence and Uniqueness Theorems : Peano's and Picard's theorems, Grownwall's inequality, Dependence on initial conditions and associated flows.
Linear Systems : Fundamental matrix, Stability of equilibrium points, Phase plane analysis, Sturm-Liouville theory.
Nonlinear systems and their stability : Lyapunov method, Non-linear Perturbation of linear systems, Periodic solutions and Poincare- Bendixson theorem.

G. RANGARAJAN

Hartman, P., *Ordinary Differential Equations*, Birkhaeuser, 1982.
Coddington, E. A. and Levinson, N., *Theory of Ordinary Differential Equations,* Tata McGraw-Hill, 1972.
Perko, L., *Differential Equations and Dynamical Systems,* Springer-Verlag, 1991.
Simmons, G. F., *Differential Equations with Applications and Historical Notes,* McGraw Hill, 1991.

MA 312 (JAN) 3:0
Commutative Algebra

Rings and Ideals : Rings and ring homorphisms; Ideals; Quotient rings; operations on ideals; Prime and maximal ideals; Nilradical and Jacobson radical.
Modules : Modules and module homomorphisms, submodules and quotient modules; Operations on submodules, Direct sums and direct products, Finitely generated modules; Exact sequences; Tensor product of modules and its properties; Algebras; Tensor product of algebras.
Rings and Modules of Fractions : Local properties; Extended and contracted ideals in rings of fractions.
Chain conditions on Modules : Ascending and descending chain conditions on modules; Noetherian rings and modules; Artinian rings.
Primary Decomposition : Primary submodules; Primary decomposition for modules; Uniqueness of isolated primary components; Associated primes.
Integral Dependence : Integral dependence; The Going-up Theorem; Integrally-closed domains; The Going-down Theorem; Noether's normalization lemma.
Discrete valuation rings and Dedekind domains : Discrete valuation rings; Dedekind domains; Fractionary ideals.

D. P. PATIL

Atiyah, M. F., and Macdonald, I. G., *Introduction to Algebra,* Addison-Wesley, 1969.
Matsumura, H., *Commutative Algebra*, W. A. Benjamin Co., New York, 1970.
Raghavan, S, Singh, B and Sridharan, R., *Homological Methods in Commutative Algebra,* TIFR Mathematical Pamphlet Number 5, Oxford University Press, 1977.
Serre, J. P, *Local Algebra* (translated from French), Springer Monographs in Mathematics, Springer-Verlag, 2000.
Zariski, O., and Samuel, P., *Commutative Algebra,* Vols I & II, Van Nostrand, 1958 and 1960.

MA 315 (JAN) 3:0
Galois Theory

Review of Groups : Groups actions, Composition series, Jordan Holder theorem, Solvable groups.
Review of Rings : Polynomial rings, Zeros of polynomials, Elementary symmetric functions and Fundamental Theorem on Symmetric Functions. Resultants and Discriminants, Euclidean rings, Principal ideal domains and Factorial rings, Factorization in polynomial rings.
Field theory : Finite Fields, Finite and Algebraic extensions. Algebraic closure, Algebraically closed fields. Proof of Fundamental Theorem of Algebra. Separable polynomials and Separable extensions. Splitting fields, Normal extensions, Galois extensions, Galois group of a polynomial. Fundamental Theorem of Galois theory, Radical extensions, Solvability by radicals, Computation of Galois groups.

ABHISHEK BANERJEE

Artin, E., *Galois Theory*, University of Notre Dame Press, 1944
Artin, M., *Algebra,* Prentice-Hall, 1994.
Jacobson, N., *Lectures in Abstract Algebra, Vols. I, II & III,* D. Van Nostrand Co. Inc., Princeton, New Jersey, 1966.
Lang, S., *Algebra,* Graduate Texts in Mathematics, Vol. 211, Springer-Verlag, 2002
Weber, H*., Lehrbuch der Algebra, Band I, II, III, Braunschweug* 1898, 1899, 1908.

MA 318 (JAN) 3:0
Combinatorics

Counting problems in sets, multisets, permutations, partitions, trees, tableaux; ordinary and exponential generating functions; posets and principle of inclusion-exclusion, the transfer matrix method; the exponential formula, Polya theory; bijections, combinatorial identities and the WZ method.

ARVIND AYYER

Stanley, R., *Enumerative Combinatorics,* Vol. 1, Second edition, 2011, Cambridge University Press.
Wilf, H., *Generating Functionology*, third edition, 2005, A. K. Peters/CRC Press.
Stanton, D and White, D., *Constructive Combinatorics,* Springer, 1986.
Erickson, M.J*., Introduction to Combinatorics*.

MA 347 (JAN) 3:0
Advanced PDE and Finite Element Method

Distribution Theory : Introduction, Topology of Test functions, Convolutions, Schwartz Space, Tempered Distributions, Fourier Transform; **Sobolev Spaces :** Definitions, Extension Operators, Continuous and Compact Imbeddings, Trace results; **Weak Solutions :** Variational formuation of Elliptic Boundary Value Problems, Weak solutions, Maximum Principle, Regularity results; **Finite Element Method (FEM) :** Introduction to FEM, Finite element solution of Elliptic boundary value problems.

THIRUPATHI GUDI

Schwartz, L., *Theories des Distributions*, Hermann, (1966).
Kesavan, S., *Topics in Functional Analysis and Applications,* John Wiley & Sons (1989).
Clarlet, P.G*., Lectures on Finite Element Method,* TIFR Lecture Notes Series, Bombay (1975).
Marti, J.T*., Introduction to Finite Element Method and Finite Element Solution of Elliptic Boundary Value Problems*, Academic Press (1986).

MA 361 (JAN) 3:0
Probability Theory

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

MANJUNATH KRISHNAPUR

Durrett, R., Probability Theory and Examples,
4th Edition, Cambridge University Press, 2010.
Billingsley, P., Probability and Measure, 3rd Edition, Wiley India.
Killenberg, O., Foundations of Modern Probability, 2nd Edition, Springer-Verlag.

Physics

Integrated Ph D Programme
Physical Sciences

Departmental Core Courses

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

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

Elective Courses:

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

PH 201 (AUG) 3:0
Classical Mechanics

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.

Banibrata Mukhopadhyay

Goldstein, H., Classical Mechanics, Second Edn, Narosa, New Delhi, 1989.
Landau, L.D., and Lifshitz, E.M., Mechanics, Pergamon, UK, 1976.
Rana, N.C., and Jog, P.S., Classical Mechanics Tata McGraw-Hill, New Delhi, 1991.

PH 202 (JAN) 3:0

Statistical Mechanics

Basic principles of statistical mechanics and its application to simple systems. Probability theory, fundamental postulate, phase space, Liouville's theorem, ergodicity, micro-canonical ensemble, connection with thermodynamics, canonical ensemble, classical ideal gas, harmonic oscillators, paramagnetism, Ising model, physical applications to polymers, biophysics. Grand canonical ensemble, thermodynamic potentials, Maxwell relations, Legendre transformation. Introduction to quantum statistical mechanics, Fermi, Bose and Boltzmann distribution, Bose condensation, photons and phonons, Fermi gas, classical gases with internal degrees of freedom, fluctuation, dissipation and linear response, Monte Carlo and molecular dynamics methods.

Arnab Rai Choudhuri

Pathria, R.K., Statistical Mechanics, Butterworth Heinemann, Second Edn, 1996.
Reif, F., Fundamentals of Statistical and Thermal Physics, McGraw Hill, 1965.
Landau, L.D., and Lifshitz E.M., Statistical Physics, Pergamon, 1980.

PH 203 (AUG) 3:0
Quantum Mechanics I

Historical foundations. Wave function for a single particle. Hamiltonian. Schrodinger equation. Probability current. Wave packets. One-dimensional problems: step, barrier and delta-function potentials. Tunnelling, scattering and bound states. Harmonic oscillator, operator approach. Matrix formulation of quantum mechanics.
Hermitian and unitary operators. Orthonormal basis. Momentum representation. Uncertainty relations. Postulates of quantum mechanics. Heisenberg representation. Ehrenfest's theorem. Three-dimensional 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-level systems. Addition of angular momentum. Spin-orbit and hyperfine interactions. Time-independent perturbation theory. Stark and Zeeman effects. Variational methods, ground state of helium atom.

Diptiman Sen

Cohen-Tannoudji, C., Diu, B., and Laloe, F., Quantum Mechanics Vol.1, John Wiley, 1977.
Landau, L.D., and Lifshitz E.M., Quantum Mechanics, Pergamon, NY, 1974.
R. Shankar, Principles of Quantum Mechanics, Springer, 2010

PH 204 (JAN) 3:0
Quantum Mechanics II

Time dependent perturbation theory. Fermi golden rule. Transitions caused by a periodic external field. Dipole transitions and selection rules. Decay of an unstable state. Born cross section for weak potential scattering. Adiabatic and sudden approximations. WKB method for bound states and tunneling. Scattering theory: partial wave analysis, low energy scattering, scattering length, Born approximation, optical theorem, Levinson's theorem, resonances, elements of formal scattering theory. Minimal coupling between radiation and matter, diamagnetism and paramagnetism of atoms, Landau levels and Aharonov- Bohm effect. Addition of angular momenta, Clebsch Gordon series, Wigner Eckart theorem, Lande's g factor. Many particle systems: identity of particles, Pauli principle, exchange interaction, bosons and fermions. Second quantization, multielectron atoms, Hund's rules. Binding of diatomic molecules. Introduction to Klein Gordon and Dirac equations, and their non-relativistic reduction, g factor of the electron.

B Ananthanarayan

Landau, L.D., and Lifshitz E.M., Quantum Mechanics, Pergamon, NY, 1974.
Cohen-Tannoudji, C., Diu, B., and Laloe, F., Quantum Mechanics (2 Vols.), John Wiley, 1977.

PH 205 (AUG) 3:0
Mathematical 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.

Subroto Mukerjee

Mathews, J., and Walker, R.L., Mathematical Methods of Physics, Benjamin, Menlo Park, California, 1973.
Dennery, P., and Krzywicki, A., Mathematics for Physicists, Harper and Row, NY, 1967.
Wyld, H.W., Mathematical Methods for Physics, Benjamin, Reading, Massachusetts, 1976.

PH 206 (JAN) 3:0
Electromagnetic Theory

Laws of electrostatics and methods of solving boundary value problems. Multi-pole expansion of electrostatic potentials, spherical harmonics. Electrostatics in material media, dielectrics. Biot-Savart Law, magnetic field and the vector potential. Faraday's Law and time varying fields. Maxwell's equations, energy and momentum of the electromagnetic field, Poynting vector, conservation laws. Propagation of plane electromagnetic waves. Radiation from an accelerated charge, retarded and advanced potentials, Lienard-Wiechert potentials, radiation multi-poles. Special theory of relativity and its application in electromagnetic theory. Maxwell's equations in covariant form: four – potentials, electromagnetic field tensor, field Lagrangian. Elements of classical field theory, gauge invariance in electromagnetic theory.

Anindya Das

Jackson, J.D., Classical Electrodynamics, Third Edn, John Wiley.
Panofsky, W.K.H., and Phillips, M., Classical Electricity and Magnetism, Second Edn, Dover.

PH 207 (JAN) 1:2
Analog, Digital and Microprocessor Electronics

Basic diode and transistor circuits, operational amplifier and applications, active filters, voltage regulators, oscillators, digital electronics, logic gates, Boolean algebra, flip-flops, multiplexers, counters, displays, decoders, D/A, A/D. Introduction to microprocessors.

K Rajan and M N Ramanuja

Horowitz and Hill, The Art of Electronics, Second Edn.
Millman and Halkias, Integrated Electronics, McGraw Hill.

PH 208 (JAN) 3:0
Condensed Matter Physics I

Drude model, Sommerfeld model, crystal lattices, reciprocal lattice, X-ray diffraction, Brillouin zones and Fermi surfaces, Bloch's theorem, nearly free electrons, tight binding model, selected band structures, semi-classical dynamics of electrons, measuring Fermi surfaces, cohesive energy, classical harmonic crystal, quantum harmonic crystal, phonons in metals, semiconductors, diamagnetism and paramagnetism, magnetic interactions.

Manish Jain

Ashcroft, N.W., and Mermin, N.D., Solid State Physics, Holt-Saunders International, NY, 1976.
Kittel, C., Introduction to Solid State Physics, 5th/6th/7th editions, Wiley International, Singapore.

PH 209 (AUG) 2:1
Analog and Digital Electronics Laboratory

Introduction to microprocessors, Intel 80x86 architecture and instruction set. Assembly and C level programming, memory and IO interfacing. Mini projects using integrated circuits, data acquisition systems. PC add-on boards. Introduction to virtual instrumentation.

K Rajan and M N Ramanuja

Hall, D.V., Digital circuits and systems, McGraw Hill International Electronic Engineering Series.
Hall, D.V., Microprocessors and Interfacing, Second Edn, Tata McGraw Hill.
Robert Bishop, Learning with LabView Express, Pearson Edn.

PH 211 (AUG) 0:3
General Physics Laboratory

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

Vasant Natarajan, Aveek Bid, D V S Muthu, G R Jayanth and Anindya Das

PH 212 (JAN) 0:3
Experiments in Condensed Matter Physics

Hall coefficient carrier mobility and life-time in semiconductors, resistivity measurement in anisotropic materials, crystal growth, crystal optics, light scattering, electron tunneling, resonance spectroscopy, coexistence curve for binary liquid mixtures, magnetic susceptibility, dielectric loss and dispersion. Meissner fraction of a high temperature superconductor, specific heat of a glass, microwave and rf absorption in high Tc materials, surface studies by STM in air, electron tunneling/STM magnetic susceptibility, calibration of a cryogenic temperature sensor (oxide/Ge sensor), resistivity vs temperature of a superconductor.

Reghu Menon, Suja Elizabeth, D V S Muthu and Ramesh Mallik

Weider, Lab. notes of electrical measurements.
Smith and Richardson, Experimental methods in low temperature physics.

PH 213 (AUG) 0:4
Advanced Experiments in Condensed Matter Physics

This lab course has two components: In the first part, the students will do the following five experiments in the Central Instruments Facility of the department to learn about the basic preparation characterization tools.
1. Laue diffraction
2. Powder diffraction
3. Differential Scanning calorimetry
4. Optical absorption spectra
5. RF sputtering
In the second part the students will do an 8-week project in a designated lab under the supervision of a faculty member.

Arindam Ghosh, R Ganesan, K R Gunasekhar and Ambarish Ghosh

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.

Biman Nath (RRI) and Tarun Saini

Choudhuri, A.R., Astrophysics for Physicists
Shu, F., The Physical Universe.
Carroll, B.W., and Ostlie, D.A., Introduction to Modern Astrophysics.

PH 231 (AUG) 0:1
Workshop practice

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

Vasant Natarajan

PH 250A (JAN) 0:6
Project – I

PH 250B (MAY) 0:6
Project – II

This two part project starts in the fourth semester of the Integrated Ph.D Programme (PH 250 A) and ends in the summer before the beginning of the 5th semester (PH 250B).

Faculty

PH 300 (AUG) 1:0
Seminar Course

The course aims to help the fresh research student in seminar preparation, presentation and participation. The seminars will be given by the course registrants, after proper guidance by the instructors.

Ramesh C Mallik and Jaydeep Basu

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.

Rahul Pandit

Ashcroft, N.W., and Mermin, N.D., Solid State Physics, Saunders College, Philadelphia.
Madelung, O., Introduction to Solid State Theory, Springer-Verlag, Berlin.
Jones, W., and March, N.H., Theoretical Solid State Physics, Dover Publications, New York.

PH 322 (JAN) 3:0
Molecular Simulation

Introduction to molecular dynamics, various schemes for integration, inter- and intra-molecular forces, introduction to various force fields, methods for partial atomic charges, various ensembles (NVE, NVT, NPT, NPH), hard sphere simulations, water 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 K Maiti

Prerequisites: Basic courses in statistical physics, quantum mechanics

D Frenkel and B Smit: Understanding Molecular Simulation (Academic Press, NY 2001)
M.P. Allen, D.J. Tildesley: Computer Simulation of Liquids (Oxford Science, 2002)

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.

Vijay Shenoy

Chaikin, P.M., and Lubensky, T.C., Principles of Condensed Matter Physics, Cambridge University Press, 1995.
Plischke, M., and Bergersen, B., Equilibrium Statistical Physics, Second Edn, World Scientific, 1994.
Sethna, J.P., Statistical Mechanics: Entropy, Order Parameters and Complexity, Oxford Univ. Press, 2006.

PH 330 (AUG) 0:3
Advanced Independent Project

Open to research students only

Faculty

PH 347 (AUG) 2:0
Bioinformatics

Biological databases: Organisation, searching and retrieval of information, accessing global bioinformatics resources using the World Wide Web. UNIX operating system and network communication. Nucleic acid sequence assembly, restriction mapping, finding simple sites and transcriptional signals, coding region identification. Similarity and homology, dot matrix methods, dynamic programming methods, scoring systems, multiple sequence alignments, evolutionary relationships, genome analysis. Protein structure classification, secondary structure prediction, hydrophobicity patterns, detection of motifs, structural databases (PDB), genome databases, structural bioinformatics. Biological systems.

S Ramakumar and K Sekar

Mount, D.W., Bioinformatics: Sequence and Genome Analysis, Second Edn, Cold Spring Harbor Laboratory Press, 2005.
Zvelebil, M., and Baum, J.O., Understanding Bioinformatics, Garland Science, 2008.
Pevsner, J., Bioinformatics and Functional Genomics, Second Edition, Wiley-Blackwell, 2009.

PH 350 (JAN) 3:0
Physics of Soft Condensed Matter

Phases of soft condensed matter, colloidal fluids and crystals, polymer solutions, gels and melts. Micelles, vesicles, surfactant mesophaes, polymer colloids, microgels and star polymers-particles with tunable soft repulsive interaction, surfactant and phospolipid membranes. Lyotropic liquid crystals. Structure and dynamics of soft matter, electrostatics in soft matter, dynamics at equilibrium. Glass formation and jamming, dynamical heterogeneity. Soft glassy rheology. Shear flow, linear and non-linear rheology, visco-elastic models, Introductory biological physics. Active matter. Experimental methods, Small angle scattering and diffraction, Dynamic light scattering and diffusive wave spectroscopy, dynamics of soft matter using synchrotron X-ray and neutron scattering, rheometry. Conforcal microscopy.

Jaydeep K.Basu
Prerequisite: Knowledge of basic statistical mechanics
Jones, R.A.L. Soft Condensed Matter, Oxford University Press, 2002
Rubinstein, M., and Colby, R.H. Polymer Physics, Oxford, 2003
Doi and Edwards, Theory of Polymer Dynamics, Clarendon, Oxford, 1988

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, mono-component and multi-component techniques. Thin film growth and characterization: concepts of ultra high vacuum, nucleation and growth mechanisms, deposition techniques such as sputtering, evaporation, LPE, MOCVD, MBE, PLD, etc., thick ness measurements and characterization such as RHEED, LEED, thin-film XRD, etc.

Suja Elizabeth and P.S.Anil Kumar

Laudise, R. A. ; Growth of Crystals, Prentice-Hall, 1970
Hurle, D.T.J.,(ed.), Hand Book of Crystal Growth, Ed., North Holland 1994
Chopra , K.L., Thin Film Phenomena, McGrow Hill, USA, 1969

PH 352 (JAN) 3:0
Semiconductor Physics and Technology

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

K S R Koteswara Rao

Seeger, K., Semiconductor Physics, Springer-Verlag, 1990.
Sze, S.M., Physics of Semiconductor Devices, Wiley, 1980.
Muller, K., and Kamins, T., Device Electronics for Integrated Circuits, John Wiley, 1977.

PH 359 (JAN) 3:0
Physics at the Nanoscale

Introduction to different nanosystems and their realization, electronic properties of quantum confined systems: quantum wells, wires, nanotubes and dots. Optical properties of nanosystems: excitons and plasmons, photoluminescence, absorption spectra, vibrational and thermal properties of nanosystems, Zone folding. Raman characterization.

A K Sood and Arindam Ghosh

Delerue,C and Lannoo, M., Nanostructures: Theory and Modelling, Springer, 2006.
Saito, R., Dresselhaus, G., and Dresselhaus, M.S., Physical Properties of Carbon Nanotubes, Imperial College Press.

PH 362 (JAN) 3:0
Matter at Low Temperatures

Properties of solid matter at low temperatures, cryoliquids, superfluid He^4, two fluid model, excitations in superfluid He^4, normal and superfluid He^3, quantized vortices, refrigeration and thermometry at cryogenic temperatures.

Ambarish Ghosh

C. Enss and S. Hunklinger, Low temperature Physics, Springer (2005)
D. R. Tilley and J. Tilley, Superfluidity and Superconductivity, Institute of Physics (1990)
F. Pobell, Matter and Methods at Low temperatures, Springer (2007).

Astronomy and Astrophysics

AA 362 (AUG) 2:0
Radiative Processes 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.

S.K.Sethi (RRI)

Rybicki, G.B. and Lightman, A.P.: Radiative Processes in Astrophysics.
Mihalas, D.: Stellar Atmospheres.

AA 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 in plasmas. From the Vlasov equation to MHD equations. Flux freezing. MHD waves. Reconnection and relaxation. Dynamo theory.

A.Satyanarayana (IIA)

Choudhuri, A.R.: The Physics of Fluids and Plasmas.
Landau, L.D. and Lifshitz, E.M.: Fluid Mechanics.
Chen, F.F.: Introduction to Plasma Physics.
V.Krishan, Atrophysical Plasmas and Fluids, Kluwer

AA 377 (AUG) 2:1
Astronomical Techniques

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

Tarun Deep Saini (IISC)

Christianson, W.N., & Hogbohm, J.A.: Radio Telescopes
Roy, A.E., & Clarke, D.: Astronomy Principles and Practice.
Kitchin, C.R.: Astrophysical Techniques.
G.F.Knoll;, Radiation Detection and Measurement (2nd ed), Wiley, NY
N.Tsoulfanidis, Measurement and Detection of Radiation (2nd ed), Taylor & Francis, Washington DC.

AA 365 (JAN) 3:0
Galaxies and the Interstellar Medium

Galactic structure: local and large scale distribution of stars and interstellar matter, the spiral structure, the galactic centre. Galactic dynamics, stellar relaxation, dynamical friction, star clusters, density wave theory of galactic spiral structure, chemical evolution in the galaxy, stellar populations. Galaxies, morphological classification of galaxies, active galaxies, clusters of galaxies, interactions of galaxies, dark matter, evolution of galaxies.

S.Sridhar (RRI)

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

AA 370 (JAN) 3:0
Stellar and High Energy Astrophysics

Stellar structure. Stellar evolution. Nuclear astrophysics. Supernovae. White dwarfs. Neutron stars. Black holes. Binary stars. Pulsars. Accretion physics. X-ray and gamma ray astronomy. Neutrino astrophysics.

F.K.Sutaria (IIA) & S Seetha (ISRO)

Clayton, D.D.: Principles of Stellar Evolution and Nucleosynthesis.
Shapiro, S., and Teukolsky, S.: Black Holes,White Dwarfs and Neutron Stars.
Longair, M.S.: High Energy Astrophysics.

AA 371 (JAN) 2:0
General Relativity and Cosmology

Foundations of general relativity. Elements of tensor analysis. Schwarzschild and Kerr spacetimes. Black hole physics. Gravitational radiation. Cosmological models. Observational tests. The early universe. The microwave background. Formation of structures.
Arnab Rai Choudhuri (IISc) and P.Chingangban (IIA)

Landau, L.D., and Lifshitz, E.M.: The Classical Theory of Fields.
Weinberg, S.: Gravitation and Cosmology.
Peebles, P.J.E.: Physical Cosmology.

AA 372 (JAN)
Numerical and Statistical Techniques

Numerical techniques in physics and astrophysics: numerical integration and interpolation. Numerical solutions of algebraic, ordinary differential and partial differential equations. Random numbers. Statistics techniques: probability, discrete and continuous random variables, central limit theorem, random walk and Poisson processes. Hypothesis testing, sampling methods, multivariate analysis, regression, time series analysis, Fourier transforms. Data reduction, error analysis. Monte Carlo techniques.

S.K.Sethi (RRI) and Tarun Deep Saini (IISc)

Bevington, Data Reduction and Error Analysis for Physical Sciences, McGraw-Hill, 2003.
Babu G. J. \& Fiegelson, E. D., Astrostatistics, Chapman and Hall, 1996.
Hoel, P. G. , Port, S. C., & Stone, C. J., Introduction to probability and Introduction to statistical theory, Houghton & Mifflin, 1971.
Press, W.H., et al.: Numerical Recipes, Cambridge University Press, 1992.

High Energy Physics

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

Radioactive decay, sub-nuclear particles. Binding energies. Nuclear forces, p-ion 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. Composition of mesons and baryons, quarks and gluons.

Sudhir Vempati

Povh, B., Rith,K., Scholz, C. and Zetsche, F., Particles and Nuclei, An Introduction to Physical Concepts, 2nd edn., Springer, 1999.
Krane, K.S., Introductory Nuclear Physics, John Wiley & Sons, New York, 1988.
Griffiths, D., Introduction to Elementary Particles John Wiley & Sons, New York, 1987.
Perkin, D.H., Introduction to High Energy Physics (Third edition), Addison-Wesley, Reading, 1987.

HE 316 (JAN) 3:0
Advanced mathematical methods in Physics

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

Apoorva Patel

Georgi. H. Lie Algebras in Particle Physics, 2nd edn., Perseus Books, 1999
Mukhi.S., and Mukunda N., Introduction to Topology, Differential Geometry and Group Theory for Physicists, Wiley Eastern, 1990
Hamemesh, M., Group Theory and its Applications to Physical Problems, Addison-Wesley, 1962.

HE 391 (AUG) 3:0
Quantum Mechanics III

Path integrals in quantum mechanics. Propagators, generating functional. 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. Canonical quantization. Interactions and Feynman diagrams. Modern topics such as graphene, Kubo formulae.

Sachindeo Vaidya

Feynman, R.P., and Hibbs A.R., Quantum Mechanics and Path Integrals, McGraw –Hill, 1965
Bjorken J.D., and Drell S., Relativistic Quantum Mechanics, McGraw-Hill 1965.
Greiner W., Relativistic Quantum Mechanics: Wave Equations, 3rd edn., Springer, 1990.
Ramond P., Field Theory, A Modern Premer, 2nd edn., Levant Books, 2007.

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

Scalar fields. Symmetries and Noether theorem. Fermi fields. Dirac Matrices, Clifford Algebra, trace theorems. Path integrals for bosons and fermions. S-matrix, LSZ reduction formula. Interacting scalar and Yukawa theories. Covariant derivatives and minimal coupling. Scattering cross-sections, optical theorem. Decay rates and non-relativistic potentials. Loop diagrams and power counting Renormalization, fixed point classification. Callan-Symanzik equations, beta functions. Global and local symmetries, Ward identities Spontaneous symmetry breaking, Goldstone theorem.

Chethan Krishnan

Srednicki, M., Quantum Field Theory, Cambridge University Press, 2007
Ryder, L.H., Quantum Field Theory, Cambridge University Press, 1985
Ramond, P., Field Theory: A Modern Primer, 2nd edn., Levant Books, 2007.
Bjorken J.D. and Drell S., Relativistic Quantum Fields, McGraw-Hill, 1965.

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

Abelian gauge theories. QED processes and Ward identities, Loop diagrams and 1-loop renormalization. Lamb shift and anomalous magnetic moments. Non-abelian gauge theories, Faddeev-Popov ghosts. BRST quantization. QCD beta function, asymptotic freedom. Anomalies. Lattice gauge theory, strong coupling expansion. Confinement and chiral symmetry breaking. Composite operators, operator product expansion. Elements of conformal field theory.

Aninda Sinha

Prerequisite: Quantum Field Theory I

Srednicki, M., Quantum Field Theory, Cambridge University Press, 2007
Peskin, M.E. and Schroeder, D.V., An Introduction to
Quantum Field Theory, Addison Wesley, 1995.
Weinberg S., The quantum Theory of Fields, Vol. I:
Foundations, Vol. II:Modern Applications, Cambridge University Press, 1996.

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

Weak interactions before gague theory. V-A theory, massive vector bosons, Spontaneous symmetry breaking. Higgs mechanism, chanrged and neutral currents, gauge symmetries and SU(2)xU(1) Lagrangian. Flavour mixing, GIM mechanism, CP violation, K/B systems, Neutrinos, Chiral Lagrangians and heavy quark effective field theories. Deep inelastic scattering, parton model. Electroweak precision measurements. Introduction to supersymmetry and extra dimension.

Rohini Godbole

Prerequisites: Quantum Field Theory I and II

Georgi, H., Weak Interactions and Modern Particle Theory, Benjamin/Cummings, 1984.
Haizen, F., and Martin, A.D., Quarks and Leptons: An Introductory Course in Modern Particle Physics, John Wiley & Sons, 1984.
Pokorski S., Gauge Field Theories, 2nd edn., Cambridge University Press, 2000
Peskin M.E and Schroeder
D.V., An Introduction to Quantum Field Theory, Addison Wesley, 1995.

HE 398 (JAN) 3:0
General Relativity

Review of tensor calculus and properties of the Riemann tensor, Killing vectors, symmetric spaces Geodesics, Equivalence principle and its application: Scalars, Fermions and Gauge fields in curved space-time. Einstein's equation and black hole solutions. Schwarzschild solution: Motion of a particles in the Schwarzschild metric. Kruskal extension and Penrose diagrams. The Reissner-Nordstrom solution, Kerr solution. Laws of black hole physics. Gravitational collapse:
Oppenheimer-Volkoff and Oppenheimer-Synder solutions, the Chandrasekhar limit.
Cosmological models: FRW metric; open, closed and flat universes.
Introduction to quantizing fields in curved spaces and Hawking radiation

Justin R. David

S. Weinberg, Gravitation and Cosmology, John Wiley and Sons 2004,
R. M. Wald General Relativity, Overseas Press 2006, G. t'Hooft, Introduction to general relativity, Introduction to the theory of black holes, http://www.phys.uu.nl/~thooft/

Centre for Earth Sciences

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

Hard Core: 24 Credits (All courses are mandatory)

ES 201 3:0	Introduction to Earth System Science
ES 202 3:0	Geodynamics
ES 203 2:1	Introduction to Petrology
ES 204 3:0	Origin and Evolution of Earth
ES 205 3:0	Mathematics for Geophysicists
ES 206 3:0	Topics in Geophysics
ES 207 0:3	Earth Science Laboratory
CE 258 3:0	Remote Sensing and GIS for Water Resources & Environmental Engineering

Project: 25 Credits

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

ES 208 3:0	Mantle Convection
ES 209 3:0	Biogeochemistry
ES 210 3:0	Plate Tectonics
ES 211 3:0	Applied Petrology
ES 212 3:0	Introduction to Earth and Planetary Magnetism
ES 213 3:0	Earth Life and Sustainability

ES 201: (AUG) 3:0
Introduction to Earth System Science

Role of geology in understanding the Earth system processes, Composition of Lithosphere, atmosphere, hydrosphere and biosphere, Earth surface processes and its consequences, earth as a dynamic planet, Planetary bodies and Formation of Universe, Early atmosphere, evolution of atmosphere through time, evolution of hydrosphere and general circulation of ocean through time. Long and short term history of cryosphere, fossilization, reconstruction of geologic time, Early evolution of the life, explosion of life, evolution and extinction, evolution of biosphere, Mass extinctions and causes, Major steps in biotic evolution and biodiversification, Gaia hypothesis, Indian climate present day, Global paleoclimate record, Paleoclimate archive from India, paleomonsoon record and the role of tectonics.

Prosenjit Ghosh

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

ES 202 (AUG) 3:0
Geodynamics

Origin, early earth and its evolution through time. Basics of rock formation, deformation and landform evolution. Tectonic processes: Gravity and geodesy, isostasy. Geomagnetism and paleomagnetism: Earth's magnetic field, types of magnetism, geomagnetic reversals, Plate tectonics and global distribution of earthquakes. Quantification of earthquakes. Interpreting seismograms, seismic waves and earth's interior, earthquake source characterization, relation to tectonic environments, earthquake and faulting processes; types of faults and relation to stress fields, moment tensors and earthquake focal mechanisms. Structure of the Earth's interior- density, seismic velocity, pressure and temperature. Lab and field components: Magnetic and Seismic data acquisition and processing.

Kusala Rajendran

Fowler, C.M.R., The solid earth: An Introduction to Global Geophysics, Cambridge University Press, 2005.
Turcotte, D., and Schubert, G., Geodynamics, Cambridge University Press, 2nd edition, 2001.

ES 203 (AUG) 2:1
Introduction to Petrology

Theory: Rock forming minerals, Micro-scale properties of minerals, Identification of silicates and oxides, Micro-textures, mineral reactions, textural equilibrium, Mineral composition, geothermometry and geobarometry, petrogenetic grid.

Practical: Field trip and sample collection, making thin-sections, mineral and rock identification using Microscope and data processing, cation calculations and *P-T* estimations.

Sajeev Krishnan

Vernon R.H., A practical guide to Rock Microstructure, Cambridge University Press, 2004.
Deer, W.A., Howie, R.A., & Zussman J., An Introduction to the Rock-Forming Minerals, Prentice Hall, 1966.
Vernon, R.H., and Clarke, G., Principles of Metamorphic Petrology, Cambridge University Press, 2008.

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

Dickin, A.P., Radiogenic Isotope Geology, Cambridge University Press, 1995.
Rollinson, H., Using Geochemical Data: Evaluation, presentation and interpretation, Longman Group, 1993.
Winter, J.D., Principles of igneous and metamorphic petrology, 2nd edition, Pearson Prentice Hall, 2010.
Langmuir C.H., and Broecker, How to build a habitable planet, Revisted and expanded edition, Princeton University Press, 2012.

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

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 206 (JAN) 3:0
Topics in Geophysics

Earth's internal structure: composition vs. mechanical properties, Stress and Strain from seismology perspective, Theory of Elasticity, Wave mechanics, Seismic tomography, Earth's free oscillation, 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, Phase transformations within the Earth, Strength of continental lithosphere.

Attreyee Ghosh

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

ES 207 (JAN) 0:3
Earth Science Laboratory

Geochemical techniques; mineral chemical techniques; sedimentology techniques; computational techniques.

Faculty

Reed, S.J.B., Electron Microprobe Analysis and Scanning Electron Microscopy in Geology, 2nd Edition, Cambridge University Press, 2010.
Reading material and notes.

ES 208/ (JAN) 3:0
CE 258
Remote Sensing and GIS for Water Resources & Environmental 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.

D Nagesh Kumar

Lillesand T.M., and Kiefer R.W., Remote Sensing and Image Interpretation, John Wiley & Sons, 2000.
Sabins, F.F., Remote Sensing - Principles and Interpretation, Freeman & Co., New York, 1986.
Heywood, I., Cornelius, S., and Carver, S., An Introduction to Geographical Information Systems, Pearson Education, 1998.

ES 208 (AUG) 3:0
Mantle Convection

Plate tectonics and mantle convection, Constraining mantle flow from seismic tomography, Maxwell viscoelastic material, Spherical harmonics, Mantle viscosity, Creep mechanisms, Governing equations, Constraints of mantle flow modeling: geoid and dynamic topography, Thermal evolution of the Earth, Convection in other planets.

Attreyee Ghosh

Schubert, G., Turcotte, D., and Olson, P., Mantle convection in the earth and planets, Cambridge University Press, 2001.
Turcotte, D., and Schubert, G., Geodynamics. Cambridge University Press, 2nd edition, 2001.
Fowler, C.M.R., The Solid Earth: An Introduction to Global Geophysics, Cambridge University Press, 2005.

ES 209 (JAN) 3:0
Biogeochemistry

Geochemistry of the Earth, Big Bang. Nucleosysthesis, origin of solar system, electronic structure of atoms, periodic tables, chemical bonds, crystals, ionic substitution, isotope geo-chronometer, chemical differentiation, chemical reactions and stability of minerals, acids and bases, salts and their ions. Thermodynamics, mineral stability, clay minerals, carbonate minerals, oxidation–reduction reaction, isotope fractionation, mixing and dilution, rate of chemical processes, chemical weathering, chemical composition of surface water, geochemical cycle (C-H-O-N-S), stable isotope geochemistry. biogeochemical cycles.

Prosenjit Ghosh and Ramananda Chakrabarti

Schlesinger, W.H., Biogeochemistry: An Analysis of Global Change, Academic press, 1997.
Faure, G., Principle and application of inorganic geochemistry, Prentice Hall, 1991.

Criss, R.E., Principle of stable isotope distribution, Oxford University Press, 1999.

ES 210 (JAN) 3:0
Plate Tectonics

Global distribution of earthquakes, focal mechanisms and relation to stress fields. Introduction to GPS, Plate motions; Euler's geometry and relative plate motions; Stable and unstable triple junctions. Plate driving forces; earthquakes in the subduction zones, seismic structure of subduction zones; Collision tectonics. Indian plate boundaries: landforms and seismicity; emphasis on Indian plate. Great subduction zone earthquakes; recurrence of great earthquakes; hazard analysis. Consequences of plate tectonics – tectonics, landforms and climate, plate tectonics through time and life evolution.
Lab and Field components; Tools to quantify earthquakes (getting familiar with Seismic Analysis Code); Field visit.

Kusala Rajendran

Cox, A., and Hart, B.R., Plate Tectonics: How it works, Wiley Blackwell Scientific Publications, Oxford, 1991.
Keary, P., and Vine, F., Global Tectonics, Blackwell Science, 1996.
Fowler, C.M.R., The solid earth: An introduction to Global Geophysics, Cambridge University Press, 2005.

ES 211 (JAN) 3:0
Applied Petrology

Using petrological datasets, tectonic applications of Micro-textures and mineral reactions, thermodynamic applications in petrology, isochemical phase diagrams and its interpretations, linking petrology to geochronology, Rock types and tectonic settings, Petrology and textural link to tectonics, Geology of southern India and applications of petrology.

Sajeev Krishnan

Vernon R.H., A practical guide to Rock Microstructure, Cambridge University Press, 2004.
Vernon, R.H., and Clarke, G., Principles of Metamorphic Petrology, Cambridge University Press, 2008.
Will, T.M., Phase equilibria in metamorphic rocks: Thermodynamic background and petrological applications (Lecture Notes in Earth Sciences) Springer,1998.
Spear, F.S, Metamorphic phase equilibria and pressure-temperature-time paths (Monograph), 2nd edition, Mineralogical Society of America; 1994.

ES 212 (JAN) 3:0
Introduction to Earth and planetary magnetism

Essential ideas: Structure and physical properties of the Earth's core, core energy budget, geomagnetic field measurement, crustal fields, a brief history of observation, possible sources of the Earth's magnetic field, power sources for the Earth's dynamo, spherical harmonic expansion of the magnetic field, elements of magnetohydrodynamics (MHD), the frozen flux approximation. Fluid dynamics of planetary cores: The Navier-Stokes equation, spherical geometry, effects of rotation, magnetic field and buoyancy, geostrophy, thermal wind. Dynamos: Kinematic dynamos, mean-field theory, the alpha and omega effects, examples, nonlinear dynamos. Advanced topics (optional): Modelling of planetary dynamos: equations, parameters, observational constraints, limitations of models, laboratory experiments.

Binod Sreenivasan

Jacobs, J.A., Geomagnetism (Volumes 1-3), Academic Press, 1988.
Moffatt, H.K., Magnetic field generation in electrically conducting fluids, Cambridge University Press, 1978.
Davidson, P.A., An introduction to magnetohydrodynamics, Cambridge University Press, 2001.
Riley, K.F., Hobson, M.P., and Bence, S.J., Mathematical methods for physics and engineering, Cambridge University Press, 2006.
Journal papers.

ES 213 (JAN) 3:0
Earth, Life and Sustainability

Basics of the habitable planet and the carbon-based life, volcanism and extra terrestrial impact governing climate change, evolution of oxygen and CO_2 in the atmosphere, major transitions and evolutionary biology, components in climate systems and feedbacks mechanism, Greenhouse gases and global energy balance, global carbon, nitrogen and sulfur cycles. Ecosystems, coupling of biogeochemical cycles and climate, paleo records of climate variability/change, anthropogenic effects, destiny of human kind from an astrobiology point of view.

Prosenjit Ghosh

Cockell, C., (Ed), An Introduction to the Earth Life System, Cambridge University Press, 2008.
Kump, L.R.., Kasting, J.F., and Crane, R.G., The Earth System Pearson Prentice Hall, Pearson Prentice Hall, 2003.
Berner, E.K., and Berner, R.A., Global Environment Princeton University Press, 2012.

Division of Electrical Sciences

Preface

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

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

All departments of the Division provide facilities for research work leading to the PhD and MSc (Engg) degrees. The following course based Master's program are offered individually or jointly by the departments of the Division.

ME in Electrical Engineering (EE Department)
ME in Telecommunications (EC Department)
ME in Computer Science and Engineering (CSA Department)
M Tech in Electronics Design and Technology (ESE Department)
ME in Systems Science and Automation (EE and CSA Departments.)
ME in Signal Processing (EE and EC Departments)
ME in Microelectronic Systems (EC and ESE Departments)

Prof Anurag Kumar
Chairman,
Division of Electrical Sciences

ME Programme

Credit requirements

Computer Science and Engineering

DURATION : TWO YEARS

No of credits: 64

Department Core: A minimum of 24 credits comprising at least 8 credits each from Pool A, Pool B and Pool C as given below.

Pool A

Course No	Credits	Title
E0 224	3:1	Computational Complexity Theory
E0 221	3:1	Discrete Structures
E0 222	3:1	Automata Theory and Computability
E0 223	3:1	Automated Verification
E0 225	3:1	Design and Analysis of Algorithms
E0 231	3:1	Algorithmic Algebra
E0 235	3:1	Cryptography

Please note Pool B remain the same

Pool B

E0 227	3:1	Program Analysis and Verification
E0 243	3:1	Computer Architecture
E0 253	3:1	Operating Systems
E0 254	3:1	Network and Distributed Systems Security
E0 255	3:1	Compiler Design
E0 261	3:1	Database Management Systems
E0 271	3:1	Computer Graphics

POOL C

E0 219	3:1	Linear Algebra and Applications
E0 230	3:1	Computational Methods of Optimization
E0 232	3:1	Probability and Statistics
E0 268	3:1	Data Mining
E1 254	3:1	Game Theory
E1 277	3:1	Reinforcement Learning

Project: 24 Credits

EP 299	0:08	August-December
	0:16	January-April Term

Electives: The balance of credits to make up the minimum of 64 credits of course work required for completing the ME Degree Programme (all at 200 level or higher) should be covered with elective courses from within/outside the department. These courses can be taken with the approval of the DCC/Faculty advisor only.

M.E. PROGRAMME
TELECOMMUNICATION
DURATION: 2 YEARS
No of credits: 64

Course No	Credits	Title
CORE COURSES: 12 Credits (All courses are compulsory)		
E2 202	3:0	Random Processes
E2 203	3:0	Wireless Communication
E2 211	3:0	Digital Communication
E2 221	3:0	Communication Networks

SOFT CORE: Minimum of 12 credits comprising at least 6 credits each from Pool A and Pool B as given below.

POOL A		
E1 244	3:0	Detection and Estimation Theory
E1 251	3:0	Linear and Nonlinear Optimization
E2 201	3:0	Information Theory
E2 204	3:0	Stochastic Processes and Queueing Theory
E9 221	3:0	Signal Quantization & Compression
POOL B		
E0 262	3:0	Multimedia Information Systems
E2 205	3:0	Error Control Codes
E2 223	3:0	Communication Protocols
E2 241	3:0	Wireless Networks
E2 242	3:0	CDMA & Multiuser Detection
E7 221	2:1	Fiber-Optic Communication
E7 231	3:0	Fiber Optic Networks
E8 242	2:1	Radio Frequency Integrated Circuits and Systems
E9 201	3:0	Digital Signal Processing
E9 202	3:0	Advanced Digital Signal Processing: Non-linear Filters
E9 211	3:0	Adaptive Signal Processing
Project 28 Credits		
EP 299	0:28	Dissertation Project
	0:03	May-July Term
	0:09	August-December Term
	0:16	January-April Term

Electives: The balance of credits to make up the minimum of 64 credits required for completing the M.E.Programme (all at 200 level or higher) Electives from within/outside the department to be taken with the approval of the DCC/Faculty advisor.

M.E. PROGRAMME
SIGNAL PROCESSING
DURATION: 2 YEARS

CORE COURSES : 12 credits (All courses are compulsory)

E1 244	3:0	Detection and Estimation Theory
E2 202	3:0	Random Processes
E1 251	3:0	Linear and Nonlinear Optimization
E2 212	3:0	Matrix Theory

SOFT CORE: Minimum of 12 credits comprising at least 6 credits each from Pool A and Pool B as given below.

Pool A

E1 213	3:1	Pattern Recognition and Neural Networks
E1 216	3:1	Computer Vision
E2 211	3:0	Digital Communication
E9 211	3:0	Adaptive Signal Processing
E9 213	3:0	Time Frequency Analysis
E9 221	3:0	Signal Quantization and Compression
E9 241	2:1	Digital Image Processing
E9 261	3:1	Speech Information Processing
E9 291	2:1	DSP System Design

Pool B

E0 265	3:0	Multimedia Systems
E2 241	3:0	Wireless Networks
E9 201	3:0	Digital Signal Processing
E9 202	3:0	Advanced Digital Signal Processing : Nonlinear Filters
E9 231	3:0	Digital Array Signal Processing
E9 243	3:0	Computer Aided Tomographic Imaging

Project 28 Credits

EP 299	0:28	Dissertation Project
	0:03	May-July Term
	0:09	August-December Term
	0:16	January-April Term

Electives: The balance of credits to make up the minimum of 64 credits required for completing the M.E.Programme (all at 200 level or higher) Electives from within/outside the department to be taken with the approval of the DCC/Faculty advisor.

M.E. PROGRAMME
MICROELECTRONIC SYSTEMS
DURATION: 2 YEARS

CORE COURSES : 18 credits

Total of 18 credits with 9 credits each from pool A and pool B

Course No	Credits	Title
Pool A : Materials, Processes and Device Technology		
E3 214	3:0	Microsensor Technologies
E3 225	3:0	Art of Compact Modeling
E3 227	2:1	VLSI Device and Process Simulation
E3 268	3:0	Advanced CMOS and Beyond CMOS
E3 222	2:1	Micromachining for MEMS Technology
E3 327	2:1	Nanoelectronics Device Fabrication and Characterization
E3 262	2:1	Electronic Systems Packaging
ME 237	3:0	Introduction to MEMS
E7 213	3:0	Introduction to Photonics
IN 214	2:1	Semiconductor Devices and Circuits
Pool B : Circuits, CAD, Systems and Applications		
E0 283	3:0	CAD Algorithms for VLSI Physical Design
E0 284	2:1	Digital VLSI Circuits
E0 285	3:0	Computer Aided Design of VLSI Systems
E0 286	3:0	Test and Verification for SOC Designs
E3 237	3:0	Integrated Circuits for Wireless Communication
E3 238	2:1	Analog VLSI Circuits
E3 231	2:1	Digital Systems Design with FPGAs
E3 239	2:1	Advanced VLSI Circuits
E3 235	2:1	Analog and Data Conversion Systems
E3 266	2:1	Electromagnetic Compatibility
E3 255	2:1	Multi-Core Architecture and Programming
E8 242	2:1	Radio Frequency Integrated Circuits & Systems
E8 262	3:0	CAD for High Speed Chip Package Systems
SE 273	3:1	Processor Design
E9 251	3:0	Signal Processing for Data Recording Channels
Project 28 Credits		
EP 299	0:28	Dissertation Project
	0:03	May-July Term
	0:09	August-December
	0:16	January-April Term

Electives : The balance of credits to make up the minimum of 64 credits required for completing the M.E.Programme (all at 200 level or higher) It can be additional courses from either Pool A or Pool B or any other courses.

M E Programme
Electrical Engineering
Duration: 2 years
No of credits: 64

Core Courses:

Pool A (One Course out of Two Courses)

Course No	Credits	Title
E1 241	3:0	Dynamics of Linear Systems
E1 251	3:0	Linear & Nonlinear Optimization

Pool B (Seven Courses out of Nine Courses)

E3 252	2:1	Digital Controller for Power Applications
E4 231	3:0	Power System Dynamics & Control
E4 233	3:0	Computer Control of Power Systems
E4 234	2:1	Advanced Computer aided Power System Analysis
E5 201	2:1	High Voltage Engineering
E5 206	3:0	HV Power Apparatus
E6 201	2:1	Power Electronics
E6 211	3:0	Electric Drives
E8 201	3:0	Electromagnetism

Project: 24 Credits

EP 299	0:24	Dissertation Project

Electives: The balance of credits to make up the minimum of 64 credits required to complete the ME degree program (all at 200 level or higher).

M E Programme
Systems Science & Automation
Duration: 2 years
64 credits

Hard Core: 13 credits

E0 251	3:1	Data Structures and Algorithms
E1 241	3:0	Dynamics of Linear Systems
E1 222	3:0	Stochastic Models and Applications
E1 251	3:0	Linear and Nonlinear Optimization

Soft core: (Minimum of 12 Credits)

E0 219	3:1	Linear Algebra and Applications
E0 223	3:1	Automated Verification
E0 233	3:1	Information Theory, Interface and Learning Algorithms
E0 235	3:1	Cryptography
E0 241	3:1	Computer Communication Networks
E0 246	3:0	Real Time Systems
E0 265	3:1	Multimedia Systems
E0 268	3:1	Data Mining
E0 270	3:1	Machine Learning
E1 213	3:1	Pattern Recognition and Neural Networks
E1 216	3:1	Computer Vision
E1 244	3:0	Detection and Estimation Theory
E1 254	3:1	Game Theory
E9 201	3:0	Digital Signal Processing
E9 241	2:1	Digital Image Processing
E9 261	3:1	Speech Information Processing

Project: 24 Credits

EP 299	0:24	Dissertation Project

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

M Tech Degree Programme
Electronics Design & Technology
Duration: 2 years

Credit Requirements

64 credits

E0 284	2:1	Digital VLSI Circuits
E2 243	3:0	Mathematics for Electrical Engineers
E3 231	2:1	Digital Systems Design with FPGAs
E3 235	2:1	Analog and Data Conversion Systems
E3 264	2:1	Industrial Design of Electronic Equipment
E3 265	2:1	Electromagnetic Compatibility
E6 202	2:1	Design of Power Converter Systems

EP 299	0:25	Project Work
	0:4	May - July
	0:6	August-December
	0:15	January-June

Electives: The balance of 18 credits to make up the minimum of 64 credits required to complete the M Tech programme at DESE. Electives from within/outside the department can be taken with the approval of the DCC/Faculty Advisor.

Electives: The balance of 18 credits to make up the minimum of 64 credits required to complete the M Tech Programme at CEDT. Electives from within/outside the department can be taken with the approval of the DCC/Faculty advisor.

E0 Computer Science and Automation

E0 219 (AUG) 3:1
Linear Algebra and Applications

Vector Spaces : Subspaces, Linear independence, Basis and dimension, orthogonality. Matrices : Solutions of linear equations, Gaussian elimination, Determinants, Eigenvalues and Eigenvectors, Characteristic polynomial, Minimal polynomial, Positive definite matrices and Canonical forms. Singular Value Decomposition, Applications.

R. VITTAL RAO

Strang G, Linear Algebra and Applications, Thomson-Brooks/Cole, 4th edition, 2006.

E0 220 (AUG) : 3:1
Graph Theory

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

SUNIL CHANDRAN L

Graph Theory, Reinhard Diestel, Springer (2010)
Introduction to Graph Theory, Douglas B. West, Prentice Hall (2001)
A. Bondy and U. S. R. Murty, Graph Theory, Springer (2008)
B. Bollabas, Modern Graph Theory, Springer (1998)

E0 221 (AUG) 3:1
Discrete Structures

Basic Mathematical Notions: Logic, Sets, Relations, Functions, Proofs. Abstract Orders: Partial Orders, Lattices, Boolean Algebra, Well Orders. Counting & Combinatorics: Pigeonhole Principle, The Principle of Inclusion and Exclusion, Recurrence Relations, Permutations and Combinations, Binomial Coefficients and Identities. Number Theory: Mathematical Induction, Divisibility, The Greatest Common Divisor, The Euclidean Algorithm, Prime Numbers, integers, Fundamental Theorem of Arithmetic, Modular Arithmetic, Arithmetic with a Prime Modulus, Arithmetic with an Arbitrary Modulus, The RSA Algorithm. Groups and Fields: Basics, Isomorphism theorems, Chinese Remainder Theorem, Finite Fields. Graph Theory: Graph Terminology and Special Types of Graphs, Bipartite Graphs and Matching, Representation of Graphs, Connectivity, Euler and Hamilton Paths and Cycles, Planar Graphs, Graph Coloring, Trees.

Arpita Patra / Bhavana Kanukurthi

K.H.Rosen, Discrete Mathematics and applications, fifth edition 2003, TataMcGraw Hill publishing Company.
C.L.Liu, Elements of Discrete Mathematics, second edition 1985, McGraw-Hill Book Company. Reprinted 2000.
Laszlo Lovasz, Jozsef Pelikan, Katalin L. Vesztergombi: Discrete Mathematics, Springer 2003.
Herstein I N : Topics in Algebra, 2 ed., Wiley India 1975.

Prerequisites (if any) : NIL

E0 222 (AUG) 3:1
Automata Theory and Computability

Finite-state automata, including the Myhill-Nerode theorem, ultimate periodicity, and Buchi'slogical 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

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 223 (JAN) (3:1)
Automated Verification

Formal models of systems: labelled state transition diagrams for concurrent processes and protocols, timed and hybrid automata for embedded and real-time systems. (2) Specification logics: propositional and first-order logic; temporal logics (CTL, LTL, CTL*); fixpoint logic: mu-calculus. (3) Algorithmic analysis: model checking, data structures and algorithms for symbolic model checking, decision procedures for satisfiability and satisfiability modulo theories.

ADITYA KANADE

Michael Huth, Mark Ryan: Logic in Computer Science: Modelling and Reasoning about Systems, CambridgeUniversity Press, 2004.
Edmund M. Clarke, OrnaGrumberg, DoronPeled: Model Checking, MIT Press, 2001.
Daniel Kroening, OferStrichman: Decision Procedures: An Algorithmic Point of View, Springer, 2008.

E0 224 (AUG) 3:1
Computational Complexity Theory

Introduction to basic complexity classes; notion of `reductions' and `completeness'; time hierarchy theorem & Ladner's theorem; space bounded computation; polynomial time hierarchy; Boolean circuit complexity; complexity of randomized computation; interactive proofs; complexity of counting.

CHANDAN SAHA

Computational Complexity - A Modern Approach by SanjeevArora and Boaz Barak.
Lecture notes of similar courses as and when required.

Prerequisites:Basic familiarity with undergraduate level theory of computation and data structures & algorithms would be helpful. More importantly, some mathematical maturity with an inclination towards theoretical computer science.

E0 225 (AUG) 3:1
Design and Analysis of Algorithms

Review of basic data structures, searching, sorting. Algorithmic paradigms, e.g., greedy algorithms, divide and conquer strategies, dynamic programming. Advanced data structures. Graph algorithms. Geometric algorithms, Randomized algorithms. NP and NP-completeness.

SATHISH GOVINDARAJAN

Jon Kleinberg and ÉvaTardos, Algorithm Design, Addison Wesley, 2005
Cormen, T.H., Leiserson, C.E., Rivest, R.L. and Stein C, Introduction to Algorithms, 2nd Edition, Prentice Hall, 2001
Aho, A.V., Hopcraft J.E., and Ullman, J.D., Design and Analysis of Algorithms, Addison-Wesley, 1974

E0 227 (AUG) (3:1)
Program Analysis and Verification

Semantics of programs: denotational semantics, operational semantics, Hoare logic. Dataflow analysis: Computing join-over-all-paths information as the least solution to a set of equations that model the program statements, analysis of multi-procedure programs. Abstract interpretation of programs: Correctness of abstract interpretation, Galois connections, dataflow analysis as an abstract interpretation. Type inference: Hindley-Milner's type inference algorithm for functional programs, subset-based and unification-based type inference for imperative programs. Pointer analysis.

K. V. RAGHAVAN and
DEEPAK D'SOUZA

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.
Research papers.

E0 228 (AUG) : 3:1
Combinatorics

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

SUNIL CHANDRAN L

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

Discrete and Combinatorial mathematics ?€? An applied introduction, R.P. Grimaldi, B.V. Ramana, Pearson Education (2007)
Introductory Combinatorics, Richard A Brualdi, Pearson Education, Inc. (2004)
Introduction to Enumerative Combinatorics, Miklos Bona, Mc Graw Hill (2007)
A walk through Combinatorics ?€? An introduction to enumeration and graph theory, Miklos Bona, World Scientific Publishing Co. Pvt. Ltd. (2006)
A course in Combinatorics, J.H. Vanlint, R.M. Wilson, Cambridge University Press ?€? (1992, 2001)
Extremal Combinatorics ?€? With applications in computer science, Stasys Jukna, Springer-Verlag (2001)
The Probabilistic methods. Noga Alon, Joel H. Spencer, P. Erdos, Wiley Interscience Publication.
Linear Algebra Methods in Combinatorics, with Applications to Geometry and Computer Science, Laszlo Babai and Peter Frankl. (Unpublished Manuscript, 1992).

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

Need for unconstrained methods in solving constrained problems. Necessary conditions 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

Fletcher R., Practical Methods of Optimization, John Wiley, 2000.

E0 231 (JAN) 3:1
Algorthmic Algebra

Basic algebraic notions: Integers, Euclidean algorithm, division algorithm, ring and polynomial rings, abstract orders and Dickson's lemma; Introduction to Gröbner bases: Term orders, multivariate division algorithm, Hilbert basis theorem, Gröbner bases and Buchberger algorithm, computation of syzygies, basic algorithms in ideal theory, universal Gröbner bases; Algebraic Applications: Hilbert nullstellensatz, implicitization, decomposition, radical and zeros of ideals; Other applications: Toric ideals and integer programming, applications to graph theory, coding, cryptography, statistics.

AMBEDKAR DUKKIPATI

Cox D, and O'Shea Ideals, Varieties and Algorithms by, Springer; 2nd ed. 1997.
Bhubaneswar Mishra, Algorithmic Algebra by, Springer, 1993.

E0 232 (AUG) 3:1
Probability and Statistics

Probability spaces, random variables and expectation,moment inequalities, multivariate random variables, sequenceof random variables and different modes of convergence, law of

largenumbers,Markov chains, maximum likelihood estimators, statistical hypothesistesting, Neyman-Pearson **lemma, exponential models.

AMBEDKAR DUKKIPATI

Introduction to Probability by Dimitri P. Bertsekas and John N. Tsitsiklis, Athena Scientific, 2nd edition, 2008.

E0 234 (JAN) 3:1
Introduction to Randomized Algorithms

Basic concepts in probability theory – event, random variables, distribution, expectations etc.; Moments and Deviations; Tail inequalities; The Probabilistic method; Markov chains and random walks; Entropy: A measure of randomness; Algebraic techniques.

CHANDAN SAHA AND ARNAB BHATTACHARYYA

Prerequisites: An undergraduate course on Algorithms and Probability theory will be helpful.

Randomized Algorithms books by Motwani and Raghavan, Probability and Computing book by Mitzenmacher and Upfal.

E0 235 (JAN) 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.

SANJIT CHATTERJEE

Douglas Stinson, Cryptography: Theory and Practice, 3rd Edition, CRCPress.
Alfred Menezes, Paul C. van Oorschot and Scott A. Vanstone, Handbook ofApplied Cryptography, CRC Press.

E0 238 (JAN) 3:1
Artificial Intelligence

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.

V. SUSHEELA DEVI

Russel S, and Norvig P, 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 239 (JAN) : 3:1
Software Reliability Techniques

Models of concurrency: multi-threading, synchronization, event-based dispatch. Model checking: model checking abstractions, context bounding, partial order reduction. Static analysis: type systems for proving dealock and race freedom, rely guarantee framework for compositional reasoning. Security vulnerabilities/attacks: attacks targeting spatial and temporal memory safety violations, injection and scripting attacks. Vulnerability detection: overflow, heap, and string analyses; information flow.

Aditya Kanade

Principles of concurrent and distributed programming. M. Ben-Ari.

Addison-Wesley, 2006.
Handbook of model checking. Springer, 2014.
Secure programming with static analysis. Brian Chess and Jacob West.
Addison Wesley, 2007.
Additional research papers.

E0 241 (JAN) 3:1
Computer Communication Networks

Introduction to computer networks; telephone networks, networking principles; switching - circuit switching, packet switching; scheduling - performance bounds, best effort disciplines, naming and addressing, protocol stack, SONET/SDH; ATM networks - AAL, virtual circuits, SSCOP; Internet - addressing, routing, end point control; Internet protocols - IP, TCP, UDP, ICMP, HTTP; performance analysis of networks - discrete and continuous time Markov chains, birth-death processes, time reversibility, queueing / delay models - M/M/1, M/M/m, M/M/m/m, M/G/1 queues, infinite server systems; open and closed queueing networks, Jackson's theorem, Little's law; traffic management - models, classes, scheduling; routing algorithms - Bellman Ford and Dijkstra's algorithms; multiple access, frequency and time division multiplexing; local area networks - Ethernet, token ring, FDDI, CSMA/CD, Aloha; control of networks - QoS, window and rate congestion control, open and closed loop flow control, large deviations of a queue and network, control of ATM networks.

SHALABH BHATNAGAR

Mitrani I, Modelling of Computer and Communication Systems, Cambridge, 1987.
Walrand J and Varaiya P, High Performance Communication Networks, Harcourt Asia (Morgan Kaufmann), 2000.
Keshav S, An Engineering Approach to Computer Networking, Pearson Education, 1997.
Bertsekas D and Gallager R, Data Networks, Prentice Hall of India, 1999.
Kurose J F, and Ross K W, Computer Networking: A Top-Down Approach Featuring the Internet, Pearson Education, 2001.

E0 243 (AUG) 3:1
Computer Architecture

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

R. GOVINDARAJAN / T. MATTHEW JACOB

J. L. Hennessy and D. A. Patterson, Computer Architecture: A Quantitative Approach, 5th Edition, Morgan Kaufmann Publishers, 2011
D. E. Culler, J. P. Singh and A. Gupta, Parallel Computer Architecture: A Hardware/Software Approach, Morgan Kaufmann Publishers, 1999
Recent Research Papers

E0 245 (JAN) 2:1
Android Sensor Programing

Objective: The objective of this course is to provide exposure to programing techniques that unravel the use of mobile devices as compute platforms enriched by the presence of location, movement and environment sensors.
Topics to be covered: Origins of JAVA: Dalvik VM, JDK, JRE; Object oriented programing: Classes and objects; Inheritance, polymorphism; Data structures; Multithreading and synchronization in JAVA; Android system architecture; Multimedia: using the microphone, speaker, video frame capture; Using Android physical sensors: accelerometer, gyroscope, magnetometer, barometer, light and proximity sensors; Error and basic filtering; Android Database; Near-field-communication; Applications: OpenCV integration for mood detection; Pulse detection from video recordings; Inventory tracking system using NFC; Hybrid mobile-cloud framework;
About the course: The course will have programming assignments (using Eclipse, JAVA, Android emulator/Android mobile device).

DIPANJAN GOPE

Greg Milette, Adam Stroud: Professional Android Sensor Programing, 2012, Wiley India

Jeff Friesen: Learn JAVA for Android Development, 2010, Apress
Ed Burnette: Hello Android, 2011, Pragmatic

E0 246 (JAN) 3:0
Real - time Systems

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

Rathna G N

Jane, W. S. Liu, Real-Time Systems, Pearson Education, New Delhi, 2001. Current literature.

E0 247 (AUG/JAN) 3:0
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. Tiny operating system, middleware support, simulation packages.

Faculty

Pre-requisite: Consent of Instructor

Raghavendra C. S, Shivalingam K. M. and Znati T, Wireless Sensor Networks, Springer, New York, 2004.
Zhao T and Guibas L, Wireless Sensor Networks, An Information processing Approach, Morgan Kauffmann, San Fransisco 2004.
Current Literature.

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

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

V. SUSHEELA DEVI

Aho A.V, Hopcroft J E, and Ullman J D, Data Structures and Algorithms, Addison Wesley, Reading Massachusetts, USA, 1983
Cormen T H, Leiserson C E, and Rivest R L, Introduction to Algorithms, The MIT Press, Cambridge, Massachusetts, USA, 1990
Weiss M A, Data Structures and Algorithms Analysis in C++, Benjamin/Cummins, Redwood City, California, USA, 1994.

E0 252 (AUG) 3:1
Programming Languages : Design and Implementation

Features and implementation of imperative, object-oriented, concurrent, distributed, logic-programming, functional, aspect-oriented, scripting, business-oriented and web programming languages. Example languages from each of the above categories would be discussed along with

their implementation details. Formal semantics would be used to enhance the understanding of the features and to assist in the design of correct implementations. However, there will be no deep discussion of the theory. This is neither a course on compiler design nor a course on the theory of programming languages. Emphasis would be on understanding the features and their implementation. Students will be required to carry out mini projects as a part of the course. The course will have large programming assignments.

Y.N. SRIKANT

Pre-requisites: None. However, programming in C/C++/Java/shell/Perl and a course on compiler design at the BE/BTech level would be helpful. There will be no overlap with the compiler design course in the CSA department (E0 255).
Robert Harper, Practical Foundations for Programming Languages, Cambridge University Press, 2012.
John Mitchell, Concepts in Programming Languages, Cambridge University Press, 2002.
John Reynolds, Theories of Programming Languages, Cambridge University Press, 2009.

E0 253 (AUG) 3:1
Operating Systems

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

K. GOPINATH / MURALI KRISHNA RAMANATHAN

Andrew S. Tanenbaum, ``Modern Operating Systems'', Third Edition, Pearson Education,Inc., 2007.
UreshVahalia, ``UNIX Internals: The New Frontiers'', Prentice-Hall, 1996.
Mauro J and McDougall R, ``Solaris Internals: Solaris 10 and OpenSolaris KernelArchitecture'' (2nd Edition), Sun Microsystems Press, 2006.
Daniel P. Bovet and Marco Cesati, "Understanding the Linux kernel", 3rd EditionO'Reilly & Associates, Inc., 2005.

E0 254 (JAN) 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.

R.C. HANSDAH

Prerequisites
Knowledge of Java is desirable, but not necessary.

William Stallings: Cryptography and Network Security: Principles and Practices, Fourth Edition, Prentice Hall, 2006.
Neil Daswani, Christoph Kern and Anita Kesavan: Foundations of Security: What Every Programmer Needs to Know, Published by Apress, 2007.
Yang Xiao and Yi Pan: Security in Distributed and Networking Systems, World Scientific, 2007.
Current Literature.

E0 255 (JAN) 3:1
Compiler Design

Review of syntax analysis and use of tools LEX and YACC; symbol tables and semantic analysis; run time storage administration and intermediate code generation; dataflow analysis, code optimization and register allocation; instruction selection and code generation; machine dependent optimizations for pipelined, and clustered architectures.

Y.N. SRIKANT/UDAY KUMAR REDDY

Aho, A.V., RaviSethi and Ullman J D, Compilers- Principles, Techniques and Tools, Addison Wesley, 1988.
Muchnick S., Advanced Compiler Design and Implementation, Morgan Kauffman, 1998.
Selected Papers.

E0 261 (JAN) 3:1
Database Management Systems

Design of Database Kernels, Query Optimization (Rewriting Techniques, Access Methods, Join Algorithms, Plan Evaluation), Transaction Management (ARIES), Distributed Databases (Query Processing and Optimization, Concurrency Control, Commit Protocols), Object-Relational Databases (Motivation, Design and Implementation), Spatial Databases (Storage, Indexing Techniques, Query Optimization), Data Mining (Association, Classification and Sequence Rules, Integration with Database Engines), Data Warehousing (Star and Snowflake Schemas, Data Cubes, View Maintenance), Semistructured and Web Databases (Data Models, Query Systems, XML, XML-Schema, Relational Storage, Compression), Mobile Databases (Broadcast Disks, Indexing Techniques), Applications to E-commerce.

JAYANT HARITSA

Elmasri R and Navathe S B, Fundamentals of Database Systems, Addison-Wesley, 3rd ed., 1999.
Ramakrishnan R and Gehrke J, Database Management Systems McGraw-Hill, 2nd ed., 1999.
Stonebraker M and Hellerstein J, Readings in Database Systems, Morgan Kaufmann, 3rd ed., 1998.
Stonebraker M, Object-Relational DBMSs Morgan Kaufmann, 1996 .
R. Mattison, Data Warehousing (Strategies, Technologies and Techniques) IEEE Press, 1998.
R. Groth, Data Mining Prentice Hall, 1998.
Recent Conference and Journal papers.

Prerequisites:
Data Structures, C or C++, Undergraduate course in DBMS

E0 262 (JAN) 3:0
Multimedia Information Systems

Multimedia Information, Delay-sensitive and Time-based Media data Modeling, Multimedia storage and retrieval techniques, Multimedia Communications: Synchronization, delay compensation, QoS management and negotiation protocols, Architectures and Issues for Distributed Multimedia Systems, Prototype Multimedia systems: Video-on-Demand, Video conferencing. Wireless Multimedia.

P. VENKATARAM/ANANDI GIRIDHARAN

P. Venkataram, Design Aspects of Multimedia Information Systems, Pearson Publishers, 2008.
W. I. Grosky, R. Jain and R. Mehrotra, The Hand Book of Multimedia Information Management, Prentice-Hall, 1997.
J. F. Koegel Buford, Multimedia Systems, Addison-Wesley, 1994.
Relevant Research Papers from the Journals/Conferences.

E0 264 (AUG) 3:1
Distributed Computing Systems

Fundamental Issues in Distributed Systems, Distributed System Models and Architectures; Classification of Failures in Distributed Systems, Basic Techniques for Handling Faults in Distributed Systems; Logical Clocks and Virtual Time; Physical Clocks and Clock Synchronization Algorithms; Security Issues in Clock Synchronization; Secure RPC and Group Communication; Group Membership Protocols and Security Issues in Group Membership Problems; Naming Service and

Security Issues in Naming Service; Distributed Mutual Exclusion and Coordination Algorithms; Leader Election; Global State, Termination and Distributed Deadlock Detection Algorithms; Distributed Scheduling and Load Balancing; Distributed File Systems and Distributed Shared Memory; Secure Distributed File Systems; Distributed Commit and Recovery Protocols; Security Issues in Commit Protocols; Checkpointing and Recovery Protocols; Secure Checkpointing; Fault-Tolerant Systems, Tolerating Crash and Omission Failures; Implications of Security Issues in Distributed Consensus and Agreement Protocols; Replicated Data Management; Self-Stabilizing Systems; Design Issues in Specialized Distributed Systems.

R.C. HANSDAH

Randy Chow, and Theodore Johnson, "Distributed Operating Systems and Algorithms", Addison-Wesley, 1997.
SukumarGhosh, “Distributed Systems: An Algorithmic Approach”, CRC Press,
2006.
Kenneth P. Birman, “Reliable Distributed Systems: Technologies, Web Services,
and Applications”, Springer New York, 2005.
G. Coulouris, J. Dollimore, and T. Kindberg, "Distributed Systems: Concepts and
Designs", Fourth Edition, Pearson Education Ltd., 2005.
Current Literature

Prerequisites: NDSS(E0 254) or equivalent course

E0 265 (JAN) 3:1
Multimedia Systems

Introduction: Video, Audio. Image compression: JPEG, GIF. Video compression: MPEG-1, -2, -4, and -7, H.261. MPEG Audio compression, AC 3, Content based retrieval, Multimedia networking: ATM, RTP, RSVP, RTSP; Multicasting: Storage and server issues, Multimedia processors, Mobile multimedia, Watermarking, Multimedia systems: VoD, video and conferencing, HDTV.

K R Ramakrishnan

Pre-requisites: Basic knowledge of DSP and Programming

Raghavan, S. V. and Tripathi, S. K., Networked Multimedia Systems: Concepts, Architecture and Design. Prentice Hall, 1998.
Raif Steinmetz, Klara Nahrtedt, Multimedia: Computing, Communication and Application, Prentice Hall, 1995.

E0 266 (AUG) 3:0
Topics in Ubiquitous Computing

Definition and Scope of ubiquitous computing, Essential Elements of Ubiquitous Networks, Architecture for ubiquitous computing: new devices and communications; and software architectures. Integrating the physical and the virtual worlds: sensing and actuation; ontology and modeling the world; awareness and perception. Interactions between humans and (ubiquitous) computers: situated (context-aware) computing; multimodal and natural interaction; disambiguation and proactivity. Social aspects of ubiquitous computing: implications on privacy, security and autonomy; system and legal safeguards; cost-benefit and market focus. Ubiquitous applications: The appropriate design; Weiser’s vision of ubiquitous computing; context awareness; mixed reality and sensible design. Illustration of some existing application domains for ubiquitous computing in such areas as gaming, workplaces, domestic spaces, museums and educational communities.

P VENKATARAM

Prerequisite: Communication Protocols/Computer Networks

References: Research papers on Ubiquitous Computing.

E0 268 (JAN) 3:1
Data Mining

Introduction to data mining. Data preprocessing and cleaning. Data visualization and exploratory data analysis. Data mining techniques. Performance evaluation. Finding patterns and rules. Predictive and descriptive modeling. Issues relating to large data sets. Applications to Web Mining and Bioinformatics.

S.K. SHEVADE / M. NARASIMHA MURTY

Tan P.-N, Steinbach M. and Kumar V., Introduction to Data Mining, Addison-Wesley, 2006.
Current Literature.

E0 270 (JAN) 3:1
Machine Learning

Introduction to machine learning. Classification: nearest neighbour, decision trees, perceptron, support vector machines, VC-dimension. Regression: linear least squares regression, support vector regression. Additional learning problems: multiclass classification, ordinal regression, ranking. Ensemble methods: boosting. Probabilistic models: classification, regression, mixture models (unconditional and conditional), parameter estimation, EM algorithm. Beyond IID, directed graphical models: hidden Markov models, Bayesian networks.
Beyond IID, undirected graphical models: Markov random fields, conditional random fields. Learning and inference in Bayesian networks and MRFs: parameter estimation, exact inference (variable elimination, belief propagation), approximate inference (loopy belief propagation, sampling). Additional topics: semi-supervised learning, active learning, structured prediction.

CHIRANJIB BHATTACHARYYA

Bishop. C M, Pattern Recognition and Machine Learning. Springer, 2006.
Duda, R O, Hart P E and Stork D G. Pattern Classification. Wiley-Interscience,
2nd Edition, 2000.
Hastie T, Tibshirani R and Friedman J, The Elements of Statistical Learning:
Data Mining, Inference and Prediction. Springer, 2nd Edition, 2009.
Mitchell T, Machine Learning. McGraw Hill, 1997.
Current literature.

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

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

Domain modeling using first-order predicate logic and relational calculus -- the tools Alloy and Event-B. Verification of finite-state systems, and concurrent systems -- Sal and Spin. Code development using refactoring -- Eclipse Refactorings. Identifying errors in code during development using dataflow analysis and logical reasoning -- FindBugs and SpecSharp. Testing and bounded-exploration of applications -- Pex.

DEEPAK D'SOUZA / K.V. RAGHAVAN

Logic in Computer Science: Modelling and Reasoning about Systems, by
Michael Huth and Mark Ryan, Cambridge University Press.
Software Abstractions: Logic, Language, and Analysis, by Daniel
Jackson, Prentice Hall International (Indian edition).
Model Checking, by Edmund M. Clarke, OrnaGrumberg, and DoronPeled, MIT Press.
Specifying software: A Hands-On Introduction, by R. D. Tennent,
Cambridge University Press.
Modeling in Event-B - System and Software Engineering, by J-R Abrial,
Cambridge University Press.
Research papers
Prerequisites: Exposure to programming, and the basics of mathematical logic and discrete structures

E0 284 (AUG) 2:1
Digital VLSI Circuits

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

BHARADWAJ AMRUTUR

N.Weste and D. Harris, CMOS VLSI Design. A Circuits and Systems Perspective, Addison Weley, 2005.
J. M. Rabaey, A. Chandrakasan, and B. Nikolic, Digital Integrated Circuits.

E0 310 (JAN) 3:1
Topics in Software Bug Detection

The course is composed of two parts; the first part will introduce the fundamentals of writing concurrent programs, its applicability in the context of building large scale software systems, different models of concurrency, introduction to various bug patterns. The second part will study the recent trends in designing program analysis techniques to detect bugs with a special emphasis on scalable approaches. A course project will help familiarize all the concepts learned as part of the lectures.

MURALI KRISHNA RAMANATHAN

Java Concurrency in Practice by Brian Goetz, Tim Peierls, Joshua Bloch, Joseph Bowbeer, David Holmes, Doug Lea, Addison-Wesley, (2006)
Slides and research papers listed on the course webpage
Prerequisites (if any) :
Previous experience with building a system will be helpful but not essential.

E0 311 (JAN) 3:1
Topics in Combinatorics

Linear Algebraic methods: Basic techniques, polynomial space method, higher incidence matrices, applications to combinatorial and geometric problems. Probabilistic Methods: Basic techniques, entropy based method, martingales, random graphs.

Sunil Chandran

ExtremalCombinatorics: Sun flowers, intersecting families, Chains and antichains, Ramsey theory
L. Babai and P. Frankl: Linear algebra methods in combinatorics with applications to Geometry and Computer Science, Unpublished manuscript.
N. Alon and J. Spenser: Probabilistic Method, Wiley Inter-science publication.
StasysJukna: ExtremalCombinatorics with applications in computer science, Springer.
Prerequisites (if any) : Basic familiarity with probability theory, linear algebra, and graph theory and combinatorics.

E0 323 (AUG) 3:1
Topics in Verification

Abstraction refinement techniques, software model checking, applications of machine learning to program verification, static analysis and type checking, program logics, programming language design, decision procedures.

ADITYA KANADE

References: Selected papers and recent literature
Pre-requisites: Automated verification (E0223)

E0 327 : 3:1 (JAN)
Topics in Program Analysis

Dataflow analysis: applications in program verification and transformation. Type systems: applications in software development and verification. Program slicing: Applications in software development. Techniques for points-to analysis. Symbolic execution: Applications in program testing. Model checking of software using abstractions. Program logics: applications in program verification. Techniques for testing and verification of concurrent programs.

Deepak D'Souza / K. V. Raghavan

Research papers.
Prerequisites: Topics in Program Analysis and Verification (E0 227)

E0 330 (JAN) 3:1
Convex Optimization and Applications

Primer: basic real analysis, linear algebra, and topology. Basic convex analysis: convex sets and functions, some analytical and topological properties, projection onto convex sets, hyperplanes, separation theorems, sub-gradients, etc.
Optimality conditions, duality, minimax theory, saddle points, KKT conditions.
Canonical programs for constrained optimization: Linear program, cone program, semidefinite program, etc. Classical Algorithms: simplex, ellipsoid, and interior-point methods. Modern Algorithms: accelerated gradient methods, FISTA, forward- backward splitting, augmented Lagrangian, ADMM, iteratively reweighted least-squares, stochastic gradient descent, online convex optimization, etc.
Discussion of some of the "big" applications of convex optimization including:
Combinatorial Optimization (Graph-Cut, Little Grothendieck Problem).
Signal Processing (Basis Pursuit, Compressed Sensing, Phase Retrieval, Approximation of L0-minimization).
Statistics (LASSO, Dantzig selector).
Recommender Systems and Distance Geometry Problems.
Machine Learning (SVM).

Kunal Narayan Chaudhury

The students get to write simple programs in Matlab (using the CVX platform) in order to get a real feel for convex optimization.
Textbooks (latest editions):
Lectures on Modern Convex Optimization, Aharon Ben-Tal and Arkadi Nemirovski.
Convex Optimization, Stephen Boyd and Lieven Vandenberghe, Cambridge University Press (available online: https://www.stanford.edu/~boyd/cvxbook/).
Convex Optimizatio

E0 331 (AUG) 3:1
Optimization for Machine Learning

Convex Optimization - Introduction, Incremental Gradient, Subgradient and Proximal Methods. Nonsmooth Convex Optimization, DC (Difference of Convex functions) Programming, Lagrangian Relaxation – Dual Decomposition. Augmented Lagrangian Methods, Cutting Plane Methods, Large-Scale Learning - Approximate Optimization.

S K SHEVADE

Optimization for Machine Learning, SuvritSra, Sebastian Nowozin and Stephen Wright (Editors), The MIT Press, Dec. 2011.
Recent Literature

Prerequisites: A course in Machine Learning or Data Mining

E0 335 (JAN) 3:1
Topics in Cryptology: Emerging asymmetric cryptosystems

Emerging encryption primitives like identity-based encryption, attribute-based encryption, predicate encryption, functional encryption etc. Cryptographic protocols for privacy preserving computation, secure storage and cloud. Revisiting the security definition and security reduction with an emphasis on concrete security and the interplay of functionality, security and efficiency of cryptographic protocols. Cryptanalysis of provable security.

Sanjit Chattarji

Prerequisite: E0 235
A selection of research papers from journals and conference proceedings

E0 343 (JAN) 3:1
Topics in Computer Architecture

Architecture and harware description languages (RTL, ISPS, vhdl). Processor architecture, Instruction level parallelism, Latency tolerance, multithreading, interconnection networks, Standards (bus, SCI), architectures, routing, Cache coherency, protocol specification, correctness, performance. Memory consistency models, synchronization primitives, parallel programming paradigms, I/O systems, Interface standards, parallel I/O, performance evaluation, analytical methods, simulation algorithms and techniques, benchmarking.

R GOVINDARAJAN / T MATTHEW JACOB

Pre-requisites: Computer Architecture, Operating Systems, Some Familiarity with Analytical Performance Evaluation Techniques.

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

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

B. UDAY KUMAR REDDY

Chapter 11 (Optimizing for parallelism and locality)Aho, Lam, Sethi, and Ullman, Compilers: Principles, Techniques, and Tools, 2nd edition
Parallel Computer Architecture - A Hardware/Software approach -Culler, Singh, Gupta, Chapter 1 Introduction
Research papers
List of research papers will be available on the course web page at thestart of the course. Papers discussed last year are at http://www.csa.iisc.ernet.in/~uday/e0358/

E0 370 (AUG) 3:1
Statistical Learning Theory

Theoretical foundations of modern machine learning. Generalizationanalysis: VC-dimension bounds, covering numbers, margin analysis,Rademacher averages, algorithmic stabilityy. Statistical consistencyanalysis.PAC learning. Online learning and regret bounds. Selectedadditional topics of current interest.

SHIVANI AGARWAL

Devroye, L, Gyorfi L, and Lugosi G, A Probabilistic Theory of PatternRecognition. Springer, 1996.
Anthony M, and Bartlett P L, Neural Network Learning: TheoreticalFoundations. Cambridge University Press, 1999.
Vapnik V N, Statistical Learning Theory. Wiley-Interscience, 1998.
Current literature.

Prerequisites : E0 270 Machine Learning (or equivalent course), Consent of the instructor

E0 371 (JAN) 3:1
Topics in Machine Learning

Selected topics of current interest in machine learning and statisticallearning theory. Examples include statistical consistency, ranking,cost-sensitive learning, and connections between learning theory and gametheory/mechanism design. Other topics may be selected based on classinterest. This course will be based on seminars and research projects.

SHIVANI AGARWAL

Current literature, including (but not limited to) recent proceedings ofNIPS, ICML and COLT conferences.

Prerequisites: Consent of the instructor

E0 374 (JAN) 3:1
Topics in Combinatorial Geometry

Fundamental Theorems: Radon's theorem, Helly's theorem. Geometric graphs: Proximity graphs, geometric results on planar graphs. Geometric incidences: Incidence bounds using cuttings

technique, crossing lemma. Distance based problems: Bounds on repeated distances and distinct distances. Epsilon Nets: Epsilon Net theorem using random sampling and discrepency theory, epsilon nets for simple geometric spaces, weak epsilon nets.

SATHISH GOVINDARAJAN

Janos Pach and Pankaj K. Agarwal, "Combinatorial Geometry", Wiley, 1st edition, 1995.
Matousek J, "Lectures on Discrete Geometry", Springer-Verlag, 1st edition, 2002.
Current Literature.

Prerequisites: The registrants should have preferably completed the "Design and Analysis of Algorithms" or "Discrete Structures" course.

E1 Intelligent Systems and Automation

E1 213 (JAN) 3:1
Pattern Recognition and Neural Networks

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

P S Sastry

Dudo, R. O, Hart P.E & Stork D. G, Pattern Classification John Wiley & sons, 2002.
Bishop C.M, Neural Network & Pattern Recognition, Oxford University Press(Indian Edition) 2003.
Prerequisite: Knowledge of Probability theory

E1 216 (JAN) 3:1
Computer Vision

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

Venu Madhav Govindu

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

E1 222 (AUG) 3:0
Stochastic Models and Applications

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

P S Sastry

Ross S.M, Introduction to Probability Models, (6th Edition), academic Press and Hardcourt Asia, 2000.
Hoel, P. G., Port, S. C., and Stone, C. J., Introduction to Probability Theory, Indian Edition, Universal Book Stall, New Delhi, 1998.
Hoel, P. G., Port, S. C., and Stone, C. J., Introduction to Stochastic Process, Indian Edition, Universal Book Stall, New Delhi, 1981.

E1 277 : 3:1 (JAN)
Reinforcement Learning

Introduction to reinforcement learning, introduction to stochastic dynamic programming, finite and infinite horizon models, the dynamic programming algorithm, infinite horizon discounted cost and average cost problems, numerical solution methodologies, full state representations,

function approximation techniques, approximate dynamic programming, partially observable Markov decision processes, Q-learning, temporal difference learning, actor-critic algorithms.

Shalabh Bhatnagar

D.P.Bertsekas and J.N.Tsitsiklis, Neuro-Dynamic Programming, Athena Scientific, 1996.
R.S.Sutton and A.G.Barto, Reinforcement Learning: An Introduction, MIT Press, 1998.
D.P.Bertsekas, Dynamic Programming and Optimal Control, Vol.I, Athena Scientific, 2005.%0

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.

Manojit Pramanik

Chi-Tsong Chen, Linear Systems Theory and Design, HBJ 1984.
Kailath,T., Linear System Theory, Prentice Hall, 1980.

E1 243 (JAN) 2:1
Digital Controller Design

Modeling of Systems – input/output relations, linearization, transfer function and state space representations, circuit averaging, bondgraph and space vector modelling; Control system essentials- representation in digital domain, z-transform, digital filters, s-z mapping, sampling issues, continuous to discrete domain conversions; Controller design-Bode method, root locus method, PID controller, State space methods, full state feedback, pole placement, estimator design, prediction, current and reduced order estimators, introduction to optimal and robust controller design.

L. Umanand

Franklin, G.F., Powell, J.D., Workman, M.L., Digital Control of Dynamic Systems, 2nd edn, Addison-Wesley, MA, USA, 1990.
Friedland, B., Control System Design-An Introduction to State Space Methods, McGraw Hill, 1987.
Lewis, F.L., Applied Optimal Control and Estimation, Prentice Hall, USA, 1992.
Umanand, L., Power Electronics: Essentials and Applications, Chapters 8 to 11, John Wiley, India, 2009.

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

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

Rajesh Sundaresan

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

E1 245 (AUG) 3:0
Online Prediction and Learning

The ability to use available data and make effective forecasts is key in many of today's data-driven intelligent systems. This course will focus on methods for learning and decision making

under uncertainty. We will explore several models, formulations and algorithms for learning with limited information, together with performance analyses. We will also study some relevant applications of these techniques, such as portfolio optimization (finance), data compression (information theory), etc.
Probability review- Concentration of measure, Martingales; Online classification- the Perceptron algorithm; Learning with experts- Weighted Majority, Multiplicative weights and the EXP3 online algorithm, Follow the Perturbed Leader; Bandits- Gittins' index, Upper Confidence Bound methods, Thompson sampling, PAC-Bayes bounds, Best arm identification; forecasting and calibration; Applications- portfolio selection, universal source coding; data compression and log-loss; Stochastic games- Blackwell approachability, Online reinforcement learning- Markov Decision Processes, the Rmax and UCRL algorithms.

ADITYA GOPALAN

Pre-requisites: Probability/stochastic processes, linear algebra. Generalmathematical maturity.
Nicolo Cesa-Bianchi and Gabor Lugosi, "Prediction, Learning and Games". Cambridge University Press, 2006.

E1 246 (AUG) 3:1
Natural Language Understanding

Syntax: syntactic processing; linguistics; parts-of-speech; grammar and parsing; ambiguity resolution; tree adjoint grammars. Semantics: semantic interpretation; word sense disambiguation; logical form; scoping noun phrases; anaphora resolution. Pragmatics: context and world knowledge; knowledge representation and reasoning;local discourse context and reference; discourse structure; semantic web; dialogue; natural language understanding and generation. Cognitive aspects: mental models, language acquisition, language and thought; theories of verbal field cognition. Applications: text summarization, machine translation, sentiment analysis, perception evaluation, cognitive assistive systems; NLP tool-kits augmentation.

C E Veni Madhavan

Allen J, Natural language understanding, Pearson Education, 1995, 2003.
Jurafsky D, and Martin J H, Speech and language processing: an introduction to natural language processing, computational linguistics and speech recognition, Pearson Education, 2000, 2003
Posner M I, Foundations of Cognitive Science, MIT Press, 1998.
Research Literature

Pre-requisites:
Familiarity with programming (optionally including scripting languages); data structures, algorithms and discrete structures; reasonable knowledge of English language.

E1 247 (AUG) 2:1
Incremental Motion Control

Introduction to various incremental motion systems, Principles of operation and classification of various types of stepper motors, control and drive circuits. Improved control and drive techniques in open and closed loop. Use of DC motors in incremental motion systems and related control techniques**.**

N S Dinesh

Kuo, B.C., Step Motors and Control Systems, SRL Publishing Co., Illinois, 1979
Proceedings of Annual Symposium on Incremental Motion Control Systems and Devices, from 1974 onwards published by IMCSS Champain

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

J.Luenberger D.G.,Introduction to Linear and Nonlinear Programming, 2nd edition, Addison Wesley, 1984.
Fletcher. R., Practical methods of Optimization John Wiley, 1980.
Edwin Chong, Stanislaw Zak, An Introduction to Optimization, Wiley Student Edition.

E1 254 (AUG/JAN) 3:1
Game Theory

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

Y. NARAHARI

Roger B. Myerson, Game Theory: Analysis of Conflict, HarvardUniversity Press, September 1997.
Martin J. Osborne, An Introduction to Game Theory, OxfordUniversity Press, 2003.
Narahari Y, Dinesh Garg, Ramasuri Narayanam, HastagiriPrakash. Game Theoretic Problems in Networ Economics and Mechanism Design Solutions. Springer, 2009.

E1 261 (AUG) 3:0
Selected Topics in Markov Chains and Optimization

Finite state Markov Chains: Rate of convergence to steady state, Eigenstructure of the transition matrix, Perron-Frobenius Theorem, Reversible transition matrices, bounds on convergence rates; Markov Chain Monte Carlo: Knapsack problem—Target distribution sampler, Gibbs sampling, Metropolis-Hastings algorithm, Simulated Annealing, Examples from Bayesian networks and inference problmes; Topics in Graph Theory: Matchings and Factors with applications, Connectivity and Paths; Enumeration combinatorics: Generating functions, Sieve methods, Posets; Semidefinite Programming: Quadratically Constrained Quadratic Programming (QCQP), Maximum Eigenvalue and Matrix Norm minimization, Applications to combinatorial problems

.

Joy Kuri, Shayan G. Srinivasa

Norris J.R., Markov Chains, Cambridge University Press., ISBN-10: 0521633966.
Hajek Bruce, An Exploration of Random Processes for Engineers (course notes for EC-534, “Random Processes”), http://www.ifp.illinois.edu/~hajek/
Bremaud Pierre, Markov Chains: Gibbs Fields, Monte Carlo Simulation and Queues,” Springer, 1999.
West Douglas, Introduction to Graph Theory, Pearson 2nd ed., ISBN-10: 0130144002.
Vandenberghe L. and Boyd S., Semidefinite Programming, in SIAM Review, March '96

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

Foundations of pattern recognition. Soft computing paradigms for classification and clustering. Knowledge-based clustering. Association rules and frequent itemsets for pattern recognition. Large-scale pattern recognition.

M. NARASIMHA MURTY

Duda R O, Hart P E, and Stork D G, Pattern Classification, John Wiley & Sons (Asia), Singapore, 2002.
Recent Literature.

E1 354 (AUG) 3:1
Topics in Game Theory

Foundational results in game theory and mechanism design: Nash's existence theorem, Arrow's impossibility theorem, GibbardSatterthwaite theorem, etc.; Selected topics in repeated games, evolutionary games, dynamic games, and stochastic games; Selected topics at the interface between game theory, mechanism design, and machine learning; Selected topics in algorithmic game theory; Modern applications of game theory and mechanism design: incentive compatible learning, social network analysis, etc.

Y. NARAHARI

Roger B. Myerson, Game Theory: Analysis of Conflict, HarvardUniversity Press, September 1997.
Rakesh V. Vohra: Advanced Mathematical Economics. Routledge, New York, NY, 2005.
Andreu Mas-Colell, Michael D. Whinston, and Jerry R. Green: Microeconomic Theory. Oxford University Press, New York, 1995.
Current Literature

Prerequisites
Elementary knowledge of linear algebra, linear programming, algorithms, game theory is useful for this course.

E1 395 (AUG) 3:0
Topics in Stochastic Control and Reinforcement Learning

Markov decision processes, finite horizon models, infinite horizon models under discounted and long-run average cost criteria, classical solution techniques -- policy iteration, value iteration, problems with perfect and imperfect state information. Reinforcement learning, solution algorithms -- Q-learning, TD(lambda), actor-critic algorithms.

SHALABH BHATNAGAR

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

Prerequisite:
A course on probability theory and stochastic processes. Knowledge of nonlinear programming is desirable.

E2 Communication Systems

E2 201 (AUG) 3:0
Information Theory

Entropy, mutual information, source coding, hypothesis testing, channel capacity, channel coding theorems, differential entropy, Gaussian channel, Kolmogorov complexity, rate distortion theory, network information theory.

NAVIN KASHYAP

T. M. Cover and J. A. Thomas, Elements of Information Theory, 2nd edition, John Wiley & Sons, 2006.
K. R. Parthasarathy, Coding theorems of classical and quantum information theory, TRIM no.45, Hindustan Book Agency, 2007.
T.M Cover and J.A Thomas, Elements of Information Theory, 2nd edition, John Wiley & Sons 2006
I. Csiszar and J. Korner, Information Theory : Coading Theorems for Discrete Memoryless Systems, 2nd edition, Cambridge University press 2011
K.R. Parthasarathy, Coding theorems of classical and quantum information theory, TRIM no. 45, Hindustan Book Agency, 2007.

E2 202 (AUG) 3:0
Random Processes

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

UTPAL MUKHERJI/ANURAG KUMAR

B. Hajek, An Exploration of Random Processes for Engineers, Course Notes, 2009.
A. Kumar, Discrete Event Stochastic Processes: Lectures Notes for an Engineering Curriculum, available on author's website.
D. P. Bertsekas and J. N. Tsitsiklis, Introduction to Probability, Athena Scientific, 2008.
G. R. Grimmett and D. R. Stirzaker, Probability and Random Processes, Oxford Univ.Press, 2001.

E2 203 (JAN) 3:0
Wireless Communication

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

NEELESH B MEHTA

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

E2 204 (JAN) 3:0
Stochastic Processes and Queueing Theory

Detailed study of stochastic processes encountered in queueing theory, namely, point processes – Poisson processes, renewal processes, Markov Processes, Markov renewal processes. Martingale theory and applications. Study of the stationary behaviour (queue lengths, delays, blocking) of single station, and multi-station queueing systems with various disciplines.

VINOD SHARMA

Prerequisite: E2 202

R. W. Wolf, Stochastic Modeling of Queues, Prentice Hall, 1989.
J. Walrand, An Introduction to Queueing Networks, Prentice Hall, 1988.
E. Cinlar, Introduction to Stochastic processes, Prentice Hall, 1975.
S. Karlin and H. Taylor, A First course in Stochastic Processes, 2nd edition, Academic Press, 1975.

E2 205 (AUG) 3:0
Error-Correcting Codes

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

P VIJAY KUMAR

P. V. Kumar, M. Win, H-F. Lu, C. Georghiades, "Error Control Coding Techniques and Applications," chapter in Optical Fiber Telecommunications IV, edited by I. P. Kaminow and T. Li, 2002.
F. J. MacWilliams and N. J. A. Sloane, The Theory of Error-Correcting Codes, North-Holland, 1977.
T. Richardson and R. Urbanke, Modern Coding Theory, Cambridge University Press, 2008.
W. C. Huffman and V. Pless, Fundamentals of Error-Correcting Codes, Cambridge University Press, 2003.
P. V. Kumar, Lecture Notes, NPTEL Course on Error-Correcting Codes, http://www.nptel.iitm.ac.in/syllabus/117108044/.

E2 208 (JAN) 3:0
Topics in Information Theory & Coding

Topics to be selected from amongst topics of current interest such as network information theory, network coding, locally decodable codes, coding for distributed storage, list decoding, polar codes.

P VIJAY KUMAR

Selected Journal Papers

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.

B SUNDAR RAJAN

S. Haykin, Digital Communication Wiley 1999.
J. G. Proakis, Digital Communication, 4th edition, McGraw Hill 2000.
S. Benedetto and E. Biglieri, Principles of Digital Transmission : with Wireless Applications, Kluwer Academic/Plenum Publishers, 1999.

E2 212 (AUG) 3:0
Matrix Theory

Preliminaries: vector spaces, inner products determinants, rank, systems of linear equations. Vector and Matrix norms. Eigen values, eigenvector and similarity. Unitary equivalence and normal matrices. Canonical forms and matrix decompositions. Symmetric and Hermitian matrices. Location and perturbation of eigen values. Positive definite matrices. Least-squares problems, generalized inverses, and the Gauss-Siedel interation,

CHANDRA R MURTHY

Horn and Johnson, Matrix Analysis, Cambridge University press, 1985
Golub and Van Loan, Matrix Computations, John Hopkins University Press, 1983
Strang G, Linear Algebra and its Applications, Third Edition, Saunders, 1988.

E2 213 (JAN) 3:0
Information -Theoretic Security

Channels models to be selected from amongst: input-constrained channels, finite-state channels, insertion/deletion channels, arbitrarily varying channels, adversarial channels, wiretap channels, channels with asymmetric errors, 2-dimensional channels

NAVIN KASHYAP

Pre-requistites: Information Theory, Error-Correcting Codes

B. H. Marcus, R. M. Roth and P. H. Siegel, Introduction to Coding for Constrained Systems, Course Notes, 2001.
R. G. Gallager, Information Theory and Reliable Communication, John Wiley and Sons, 1968.
J. Justesen and S. Forchhammer, Two-dimensional Information Theory and Coding, Cambridge Univ. Press, 2010.
Selected journal papers

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.

A CHOCKALINGAM

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 223 (AUG) 3:0
Communication Protocols

Protocols and Architectures, The Layered Approach: The OSI Model, The TCP/IP Protocol Suite, Principles of Internetworking, Distributed Applications: Network Management, E-mail. Protocol Engineering, Formal specification of protocols, Specification Languages: Estelle, SDL, Lotos, Protocol Verification, Protocol Performance Testing. Validation Techniques, Protocol analysis and synthesis, conformance testing.

P VENKATARAM / ANANDI GIRIDHARAN

P. Venkataram and S. K. Manvi, Basics of Communication Protocol Engineering, PHI, 2004.
A. S. Tannenbaum, Computer Networks, Prentice-Hall, 1997.
W. Stallings, Data and Computer Communications, Prentice-Hall, 1996.
Relevant Research papers from Journals/Conferences.

E2 232 (AUG) 2:2
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
Lab: Scripting, network tools; Wireshark, tcpdump, netperf, hping2, network programming, TCP/IP networking in Linux

T.V.Prabhakar, Haresh Dagale, Joy Kuri

E2 241 (JAN) 3:0
Wireless Networks

Macromodels for power attenuation in mobile wireless networks (path loss, shadowing, multipath fading). Link budget analysis. Cellular networks; FDM/TDM/TDMA: spatial reuse, cochannel interference analysis, cell sectoring, channel allocation (fixed and dynamic), handover analysis, Erlang capacity analysis. CDMA: interference analysis, other cell interference, hard and soft handovers, soft capacity, and Erlang capacity analysis; examples from GSM, IS95 and WCDMA networks. ARQ and TCP over mobile wireless access links. Power control; cross layer design; impact of modern physical layer. Technologies such as MIMO and OFDM. Channel and power allocation in OFDMA access networks. Wireless random access networks: ALOHA, CSMA/CA; IEEE 802.11 WLANs and their analysis. Wireless ad hoc networks: links and random topologies, connectivity and capacity, scaling laws, scheduling in ad hoc networks; wireless ad hoc internets and sensor networks.

ANURAG KUMAR / UTPAL MUKHERJI

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

E2 242 (JAN) 3:0
CDMA & Multiuser Detection

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

A CHOCKALINGAM

A. J. Viterbi, CDMA Principles of Spread Spectrum Communications, Addison Wesley, 1995.

S. Verdu, Multiuser Detection, Cambridge Univ.Press, 1998.
H. Wymeersch, Iterative Receiver Design, Cambridge Univ. Press, 2007.
D. Tse and P. Viswanath, Fundamentals of Wireless Communication, Cambridge University Press, 2005.
Research Papers in Journals and Conferences

E2 243 (JAN) 3:0
Mathematics for Electrical Engineers

Fourier series and Fourier transform LTI system, signals, sampling and sampling theorem, discrete and continuous signals, DFT. Linear algebra: linear system of equations range and null space, singular value decomposition of a matrix, pseudoinverse of a matrix, optimal solution of a system. Probability: random experiments, sample space, events, sigma algebra, probability measure random variables, probability distribution function, discrete and continuous distributions, joint distributions, distribution of functions of random variables, some random processes.

R. Vittal Rao

Bracewell R., Fourier Transform and its applications, (3rd edition) McGraw Hill, 2000
Strang G., Linear Algebra and its applications, (4th edition) Thomson, 2006
Leon-Garcia A., Probability, statistics and Random Processes for Electrical Engineers, Pearson Prentice Hall, **2008.**

E2 301 (AUG) 3:0
Topics in Multiuser Communication

Channel capacity for multiple access channels, broadcast channels, relay channels, wireless fading channels, multihop wireless networks and physical layer security.

VINOD SHARMA

Pre-requisite: E2 202, E2 201
T. M. Cover and J. A. Thomas, Elements of Information Theory, 2nd Edition, John Wiley & Sons, 2006.
Abbas El Gamal and Young – Han Kim, Network Information Theory, Cambridge 2012.
Research papers in journals and conferences.

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

The goal of this advanced/research course is to introduce students to the underlying theory, design techniques, and analytical tools for understanding and improving next generation wireless systems. A course will focus on beyond third generation (B3G) cellular standards such as Long Term Evolution (LTE) and IEEE 802.16 WiMAX. The course will first develop the basics required to understand the physical layer of B3G systems. This includes performance analysis of digital communication systems over fading channels, rate and power adaptation, and multi user diversity techniques. As a case study of will cover the LTE standard, its air interface, physical and logical channels, and physical layer procedures. Thereafter, advanced technologies that are likely to impact B3G standards such as cooperative communications and cognitive radio will be covered through a survey of research papers. Digital communication over fading channels; Adaptation; Multi-user systems; Long Term Evolution (LTE) standard overview, Cooperative communications and relays: Relation to multi-antenna techniques, Cognitive radio.

NEELESH B MEHTA

Pre requisite: E2 211 “Digital Communications”

References
“LTE The UMTS Long Term Evolution,” Stefania Sesia, Issam Toufik, Matthew Baker, John Wiley & Sons, 1st ed., 2009.
“Wireless Communications,” Andrea Goldsmith, Cambridge University Press, 1st ed., 2005.

"Digital Communications," J. Proakis, McGraw Hill Science/Engineering/Math, 4th ed., 2000.
3GPP technical specifications available online at http://www.3gpp.org/.

E2 312 (AUG) 3:0
Random Matrix Theory for Wireless Communications

Chandra R. Murthy Course Description: The goal of this course is to cover the basics of random matrix theory and show how it can be applied to solve a various problems in wireless communications. The following topics will be covered: Stieltjes transform method, free probability theory, combinatoric approaches, deterministic equivalents, and spectral analysis methods for statistical inference. In the second half of the course, these theoretical concepts will be applied to a variety of problems in signal processing and wireless communications to show the utility of random matrix theory in solving real-world engineering problems.

CHANDRA R MURTHY

Prerequisites: Random Processes, Matrix Theory
Romain Couillet and Merouane Debbah, "Random Matrix Methods for Wireless Communications," Cambridge University Press, 2011.
Antonia M. Tulino and Sergio Verdu, "Random Matrix Theory and Wireless Communications," NowPublishers, 2004.

E2 331 (JAN) 3:0
Advanced Course in Coding Theory

Topics to be selected from amongst: Quantum Error Correcting Codes; Coding for Cooperative Communication; Network Coding; Coding for Multiuser Communication; Lattices and their applications in MIMO Communication.

B SUNDAR RAJAN

M.A. Nielsen and I .L. Chuang, Quantum Computation and Quantum Information, Cambridge University Press, 2006,
R.W Yeung., Information Theory and Network Coding, Springer, 2008.
T.M. Cover and J.A Thomas, Elements of Information Theory, 2nd Edition, Wiley Interscience, 2006.
D. Tse and P Viswanath, Fundamentals of Wireless Communication, Cambridge University Press, 2005.
Selected Journal Papers.1

E3 Electronic Drives

E3 214 (AUG) 3:0
Microsensor Technologies

Micro-sensors and micro-actuators; MEMS and MOEMS; classification and characteristics; principles of microsensors - micromechanics, electro-mechanical coupling, electromagnetics, opto-mechanical effects; thermal and fluidic properties; modeling and simulation; technology - lithography, deposition, diffusion, metallization, bulk and surface micromaching; commercial fabrication processes; pressure, vibration, acceleration, rotation, temperature, magnetic field, radiation, chemical and bio microsensors; surface acoustic wave microsensors; mciro-opto-electro-mechanical sensors; fiber optic sensors; smart structures; sensors arrays and distributed sensing; noise in microsensors; control and signal processing; automotive, aerospace, industrial, and biomedical applications.

T. SRINIVAS/T. BADRINARAYANA

J. W. Gardner, V. K. Varadan and O. O. Awadelkarim, Microsensors, MEMS and Smart Devices, John Wiley, 2002
S. D. Senturia, Microsystem Design, Kluwer- Academic Publishers, 2001
P. Raichoudhury (Ed), MEMS and MOEMS Technology and Applications, SPIE Press, 2000.
Current literature: Special issues of journals and selected review articles

E3 222 (JAN) 2:1
Micromachining for MEMS Technology

Micromachining Concepts, Benefits and Materials. Surface Micromachining and Related Technologies. Bulk Micromachining. Micromachining for high aspect ratio microstructures. Monolithic Integration of micromachined mechanical devices and Microelectronics circuits: merits and complexities. Laboratory classes to gain hands on experience on the Micromachining and related Technology.

NAVAKANTA BHAT/ K. N. BHAT

Chang Liu, “Foundations of MEMS”, (ILLINOIS ECE Series), Pearson Education International, 2006
Gregory TA Lovacs, “ Micromachined Transducers Source Book”, WCB McGraw Hill, NY, Singapore, 1998

E3 225 (AUG) 3:0
Art of Compact Modeling

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

Santanu Mahapatra

Tsividis, Y., Operation and Modelling of the MOS Transistor, Oxford University Press, 2012
Arora, N., MOSFET modeling for VLSI simulation: Theory and Practice, World Scientific Publishing Company, 2007
Foty, D., MOSFET modeling with SPICE, Prentice Hall, 1997
Liu, W., MOSFET Models for SPICE Simulation, Wiley-IEEE Press, 2001
Enz C and Vittoz E, Charge-based MOS transistor modeling, Wiley, 2006
Gildenblat, G., Compact Modeling: Principles, Techniques and Applications, Springer, 2010

E3 231 (JAN) 2:1
Digital Systems Design with FPGAs

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

Kuruvilla Varghese

Wakerly, J. F., Digital Design: Principles and Practices 4th Edition, Pearson, 2008
Skahil, K., VHDL For Programmable Logic 1st Edition, Pearson, 2004
FPGA Data sheets, Application Notes
Current literature from relevant journals and conference proceedings

E3 235 (AUG) 2:1
Analog and data conversion systems

Linear IC applications. Design and error budget analysis of signal conditioners for low level ac and DC applications. 4-20 ma current transmitters. Design of linear power supplies. Designing for single supply low power consuming circuits. Design of analog circuits for capacitive and inductive transducers. Analog to digital and digital to analog converters. SHA and analog multiplexers.

M.K. Gunasekaran

Franco, S., Design with operational amplifiers and analog integrated circuits. Mc. Graw Hill book Co. 1988.
Horowitz, P., and Hill, W., The art of electronics (2nd edition), Cambridge University Press. 1992.

E3 237 (JAN) 3:0
Integrated circuits for Wireless Communication

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

GAURAB BANERJEE

Prerequisite: E3 238

B. Razavi, RF Microelectronics
T. H. Lee, The design of CMOS Radio-frequency Integrated Circuits

E3 238 (AUG) 2:1
Analog VLSI Circuits

Introduction to CMOS analog circuits, MOS transistor DC and AC small signal parameters from large signal model, Common source amplifier with resistive load, diode connected load and current source load, Source follower, Common gate amplifier, Cascode amplifier, Folded cascode, Frequency response of amplifiers, Current source/sink/mirror, Matching, Regulated cascode current source, Bandgap reference, Differential amplifier, Gilbert cell, Op-Amp, Design

of 2 stage Op-Amp, DC and AC response, Frequency compensation, slew rate, Offset effects, PSRR, Noise, Comparator, Sample and Hold, Switched capacitor filters, DAC, ADC, Lowpower CMOS circuits.

GAURAB BANERJEE

B. Razavi, Design of Analog CMOS Integrated Circuits, McGraw Hill 2001
Grey, Meyer, Hurst & Lewis, "Analysis & Design of Analog Integrated Circuits," Wiley International.

E3 239 (JAN) 2:1
Advanced VLSI Circuits

Dynamic circuit design, memories, TCAM, Multipliers, adders I/O circuits, timing control loops, power supply and clock distribution, sub threshold circuit design, low power circuit design

BHARADWAJ AMRUTUR

E3 252 (JAN) 2:1
Digital Controllers for Power Applications

Review of analog and digital electronics, operational amplifiers, D/A and A/D converters, semiconductor memories. Sampling of continuous-time signals, anti aliasing filter, discrete-time systems, digital systems, finite state machines. Arithmetic for computers, fixed-point and floating-point and numbers, digital circuits for fixed-point and floating-point arithmetics. Architecture, features and instruction set of a specific DSP processor; assemble programming; development tools. Interfacing examples. Hands-on exercises – data acquisition, control of power electronic converters and motor drives, digital techniques in power systems measurement and protection; mini-project.

Indraneel Sen/U J Shenoy

Sedra, A.S., and Smith, K.C., Microelectronic Circuits, Fifth Edn, Oxford University Press.
Astrom, K.J., and Wittenmark, B., Computer-controlled systems: Theory and design, Prentice Hall, 1996.
Hintz, K., and Tabak, D., Microcontrollers: Architecture, Implementation and Programming, McGraw Hill, 1992.
Patterson, D.A., and Hennnessy, J.L., Computer organization and design: The hardware/software interface, Third Edn, Elsevier.
Technical datasheets, user guides and application notes from manufacturers.

E3 257 (JAN) 2:1
Embedded Systems – I

Introduction to embedded computing, Introduction to RISC architecture, Introduction to embedded software development, S/W Development environment - Cross Compiler, Linker, Debugger, Stand-alone systems. Introduction to ARM and Cortex architecture and ARM/THUMB instruction set, Introduction to Memories, Interfacing memory with processor, Peripherals. Clocks and Power Management.

Haresh Dagale

Hennessy, J.L. and Patterson, D.A., Computer Architecture: A Quantitative Approach Computer Systems (5th edition), The Morgan Kaufmann Series Elsevier , 2012.
Furber, S., ARM System-on-Chip Architecture (2nd Edition), Pearson Education Limited. 2000.
Levine J. R., Linkers and Loaders, Morgan Kaufmann Publishers, 1999.
The Definitive Guide to the ARM Cortex-M3, (2nd Edition), Newnes (imprint of Elsevier), 2009.

E3 258 (JAN) 2:1
Design for Internet of Things

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

H S Jamadagni, T V Prabhakar

Barry, P., and Crowley, P., Modern Embedded Computing, Morgan Kaufmann, 2012
Wolf, M., Computers as components Third edition, Morgan Kaufmann, 2012
Other online references to be provided during the course

E3 262 (AUG) 2:1
Electronic Systems Packaging

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

G V Mahesh

Rao R. Tummala, Fundamentals of Microsystems Packaging, McGraw Hill, NY, 2001.
Brown, W.D., Advanced Electronic Packaging, IEEE Press, 1999.
Web-based Current literature.

E3 264 (AUG) 2:1
Industrial Design of Electronic Equipment

Introduction to industrial design. Product design methodology. Product planning, data collection. Creativity techniques. Elements of aesthetics. Ergonomics. Control panel organization. Graphic User Interface (GUI) design. Structure, materials, processes and product finishes. Product detailing.

N V Chalapathi Rao, Guest Faculty

Current Publications in Industrial Design.

E3 266 (JAN) 2:1
Electromagnetic Compatibility

Noise pickup modes and reduction techniques for analog circuits. Use of co-axial cables. Conducted and radiated noise emission and control in power circuits. EMI induced failure mechanisms in power circuits. Power supply and ground line distribution in digital circuits. Cross talk and reflection issues in digital circuits. PCB design for signal integrity. Shielding of electronic equipment. ESD issues. EMC standards and test equipment.

M K Gunasekaran

Otto, H.W., Noise reduction techniques in Electronic systems, 2nd Edition, John Wiley Interscience, New York 1988
Paul, C.R., Introduction to electromagnetic compatibility, John Wiley and sons, Inc., 1991.

E3 268 (JAN) 3:0
Advanced CMOS and beyond CMOS

CMOS Scaling, Multiple Gate MOSFETs, Tunnel FET, Nano Materials for MOSFET channel, Next generation electronic switch

Santanu Mahapatra

Taur, Y. and Ning, T. H., Fundamentals of Modern VLSI Devices, Cambridge University Press, 2009
Current literature from relevant journals and conference proceedings

E3 269 (AUG) 0:1
Electronic Circuits Laboratory

Linear and nonlinear applications of operational amplifiers, inverting and non-inverting amplifiers, differential amplifiers, phase-shifting circuits, active filters, oscillators, comparators waveform generating circuits. Logic circuits, flipflops, counters and timers. Voltage controlled oscillators, phase locked loops, frequency multiplier and divider circuits. Electronic circuits relevant for power electronic converters, power systems measurements and protection of power apparatus.

G Narayanan and U J Shenoy

Horowitz, P., and Hill, W., The art of electronics, Cambridge University Press, 1989.
Millman, J., and Halkias, C.C., Integrated electronics: Analog and digital electronic circuits and systems, Tata McGraw Hill.
Sedra, A.S., and Smith, K.C., Microelectronic circuits, Fifth Edn, Oxford University Press.
Technical datasheets and application notes from manufacturers.

E3-271 (AUG) 3:0
Reliability of Nanoscale Circuits and Systems

Carrier transport and carrier energy fundamentals, avalanche multiplication and breakdown, hot carrier induced (HCI) degradation mechanism, NBTI/PBTI, TDDB, GOI and Electromigration, ESD and latch-up phenomena, Test models and methods, ESD protection devices and device physics, Advance ESD protection devices, high current effects and filaments, Negative differential resistance, Physics of ESD failure, ESD protection methodology, ESD protection circuits, ESD protection for Analog/RF and mixed signal modules, General rules for ESD design, layout considerations for ESD and latch-up protection, understanding parasitics, ESD circuit simulation

basics and requirements, ESD TCAD simulation methodology, System on Chip overview and system ESD aspects, case studies related to product failures and solutions used

Mayank Shrivastava

Prerequisites **:** Solid State device Physics
Basics of MOS and Bipolar junction transistors

Review Papers on NBTI/PBTI, HCI Degradation, TDDB, Electromigration
ESD in Silicon Integrated Circuits by Ajith Amerasekera and Charvaka Duvvury, Wiley publication
Basic ESD and I/O Design by Sanjay Dabral and Timothy J. Maloney, Wiley publication
Advanced Simulation Methods for ESD protection development by Kai Esmark, Harald Gossner and Wolfgang Stadler, Elsevier Publication
ESD Physics and Devices by Steven H. Voldman, Wiley publication

E3-272 (JAN) 3:0
Advanced ESD devices, circuits and design methods

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

Mayank Shrivastava

Pre-requisite: ESD Devices and Circuit Design
ESD Protection Device and Design for Advanced CMOS Technologies by Oleg Semenov, Hossein Sarbishaei and Manoj Sachdev, Elsevier
ESD RF Technology and Circuits by Steven H. Voldman, Wiley
Nanoelectronics – Nanowires, Molecular Electronics and Nanodevices by Krzysztof Iniewski, McGraw Hill, 2011
Physical Limitations of Semiconductor Devices by Vladislav A. Vashchenko and V.F. Sinkevitch, Elsevier
Transient - Induced Latchup in CMOS Integrated Circuits by Ming-Dou Ker and Sheng-Fu Hsu, Wiley 2009
ESD Design for Analog Circuits by Vladislav A. Vashchenko and Andrei Shibkov, Elsevier

E3-274 (AUG) 3:0
Power Semiconductor Devices and Physics

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

GaN and SiC Power MOS devices: Advantage of high bandgap materials, High bandgap material physics, various GaN/SiC devices, device physics and design essentials, GaN/SiC device manufacturing technology; breakdown voltage and on-resistance trade-off, parasitic capacitance and resistances, DC, RF and switching characteristics; quasi saturation behavior, self heating effects and safe operating area (SOA); state-of-the-art GaN/SiC devices and ongoing research.
IGBTs and SCR: IGBTs and SCR device physics and device design essentials, breakdown voltage and on-resistance trade-off, self heating effects and filament formation.

Mayank Shrivastava

Prerequisites: Basic Semiconductor Physics
Semiconductor power devices: Physics of operation and fabrication technology**,** Sorab Khushro Ghandhi, Wiley, 1977
Advanced Power MOSFET Concepts**,** B. Jayant Baliga, 2010
High Voltage Devices and Circuits in Standard CMOS Technologies**,** Hussein Ballan, Michel Declercq
Fundamentals of Power Semiconductor Devices, B. Jayant Baliga, 2010
Smart Power ICs: Technologies and Applications**,** edited by Bruno Murari, Franco Bertotti, Guiovanni A. Vignola
Silicon Carbide Power Devices**,** B. Jayant Baliga, World Scientific, 2005
Integrated Power Devices and TCAD Simulation**,** Yue Fu, Zhanming Li, Wai Tung Ng, Johnny K.O. Sin
Advanced High Voltage Power Device Concepts, B. Jayant Baliga, 2011

E3 327 (AUG) 3:0
Nanoelectronics Device Technology

Overview of Nanoelectronics devices and materials requirement, MOS capacitor as a building block of FET: Ultrathin SiO2 growth, High-k dielectrics, Physical Vapour Deposition (PVD), Non idealities in MOS structure, metal gate electrodes and work function engineering, C-V and I-V characteristics Nano MOSFET performance metrics, non classical transistor structure : Transport in Nano MOSFET, velocity saturation and overshoot, ballistic transport, Silicon On Insulator (SOI) –PDSOI and FDSOI, Multigate FET, metal-semiconductor source/drain junctions, Germanium Nano MOSFETs, Effect of strain and quantization on transistor performance, Compound semiconductor MESFETs and MOSFETs, Hetero structure MOSFETs, Emerging Research Devices and architectures, Characteristics of nanomaterials; scaling of properties with particle size; quantum confinement; device concepts based on nanomaterials and nanostructures; some methods for the preparation and characterization of nanomaterials and structures.

Navakanta Bhat / K. N. Bhat/ S A Shivashankar

Reference Books:
Fundamentals of Modern VLSI Devices by Taur and Ning, Cambridge University Press
Solid State Electronic Devices by Streetman and Banerjee
Fundamentals of Electronic Devices by Achutan and Bhat, McGraw Hill
MOS (Metal Oxide Semiconductor) Physics and Technology" by E.H. Nicollian and J.R.Brews, Wiley Publishers.
Silicon VLSI Technology by Plummer, Deal, and Griffin
ULSI Technology" by S. M. Sze, McGraw Hill
Encyclopedia of Materials Characterization" Edited by Brundle, Evans, Wilson, Elsevier
International Technology Roadmap for Semiconductors (ITRS)
Current literature from journals and conference proceedings

E4 Power Drives

E4 221 (AUG) 3:0
DSP and AI Techniques in Power System Protection

Evolution in protection systems, Introduction to computer relaying, software tools for digital simulation of relaying signals. Performance issues of current and voltage transformers, signal conditioning, sampling and analog to digital conversion, real-time considerations, hardware design concepts – microcontroller/DSP based, single/multiprocessor based. Relaying algorithms, software considerations. Digital protection schemes for transmission lines, generators, and transformers, adaptive relaying, integrated substation protection and control. New relaying principles based on AI techniques, ANN approach and Fuzzy Logic (FL) methods for fault detection and fault location, Playback simulators for testing of protective relays.

U J Shenoy

Warrington, A.R., and Von, C., Protective Relaying: Theory and Practice, Vol. II, Chapman and Hall, 1970.
IEEE Tutorial Course on Microprocessor Relays and Protection Systems, Power Systems Research Group, University of Saskatchewan, 1979 and 1987.
Phadke, A.G., and Thorp, J., Computer Relaying for Power Systems, John Wiley, Inc. 1988.
IEEE Tutorial Course on Advancement in Microprocessor Based Protection and communication, 1997.
Technical papers from IEEE transactions, CIGRE, IEE journals.

E4 231 (AUG) 2:1
Power System Dynamics and Control

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

Indraneel Sen

Padiyar, K.R., Power System Dynamics, Stability and Control, Interline Publishing, 1996.
Machowski, J., Bialek, J.W., and Bumby, J.R., Power System Dynamics and Stability, John Wiley and Sons, 1997.
Prabha Kundur, Power System Stability and Control, Tata McGraw Hill Edn, 2006.
Current Literature.

E4 232 (AUG) 3:0
Intelligent Systems applications in Power Systems

Review of Artificial Intelligent (AI) techniques. Overview of the current practice of power systems planning and operation and the problems of the basic mathematical tools used. Knowledge based systems/expert systems, basic requirements and techniques for building knowledge-based systems. Fuzzy systems and control, applications of fuzzy control. Artificial Neural Networks (ANNs). Application examples in power systems, decision and control in monitoring operation, fault locators, restoration.

D Thukaram

Wang, Li-Xin, A Course in Fuzzy Systems and Control, Prentice-Hall Intl, Intl Edition, 1997.
Rao, V.B., and Rao, H.V., C++ Neural Networks and Fuzzy Logic, BPB Publcations,1996.
Yegnanarayana, B., Artificial Neural Networks, Prentice Hall of India, New Delhi, 1999. Current Literature.

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

State transition diagram, security-oriented functions, data acquisition, SCADA/EMS system, state estimation, load forecasting, security assessment. Automatic Generation Control (AGC). Voltage stability assessment, reactive power/voltage control, security oriented economic load despatch, preventive and restorative controls, application of intelligent techniques in energy control centres, computer configuration for higher order power system control.

D Thukaram

Wood, A.J., and Wallenberg, B.F., Power Generation, Operation and Control, John Wiley and Sons, 1984.
Russel, B.D., and Council, M.E., Power System Control and Protection, Academic press, 1978.
Miller, T.J.E., Reactive Power Control in Electrical Power System, John Wiley, USA.
Prabha Kundur, Power System Stability and Control, McGraw Hill Inc., 1983.
Kusic, G.L., Computer Aided Power System Analysis, Prentice Hall of India Pvt. Ltd, 1989.

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

Review of matrix representation of power systems, fault analysis, load flow analysis, sparse matrix techniques, fast-decoupled solution, programming consideration for large system, 3 phase models, AC/DC systems, contingency analysis.

P S Nagendra Rao

Kusic, G.L., Computer Aided Power System Analysis, Prentice Hall of India Ltd, 1989.
Stagg, G.W., and El Abiad, A.H., Computer Methods in Power System Analysis, McGraw Hill.
Anderson, P.M., Analysis of Faulted Power Systems, Iowa State University Press.
Arilaga, J., Arnold, C.P., and Horker, B.J., Computer Modelling of Electrical Power Systems, Wiley, 1984.
Prabha Kundur, Power System Stability and Control, McGraw Hill Inc, 1983.

E4 236 (JAN) 3:0
Planning and Management of Deregulated Power Systems

Operation of vertically integrated power systems, models and examples of deregulated operation. New operation and planning policies, generation scheduling, independent power producers, cogeneration, optimal dispatch based on offers and bids, unit commitment, power wheeling, transmission pricing and congestion, allocation of spinning reserve, transmission planning under uncertainty, demand side bidding, pricing schemes, competitive electricity markets.

D Thukaram and P S Nagendra Rao

Lai, L.L. (ed.), Power System restructuring and deregulation, John Wiley and Sons Ltd, 2001.
Bhattacharya, K., Bollen, M.H.J., and Daalder, J.E., Restructured Power Systems, Kluwer Academic Publishers, 2001.
Ilic, M., Galiana, F., and Fink, L., Power System restructuring Engineering and Economics, Kluwer Academic Publishers, 1998.

E5 High Voltage and Insulation Engineering

E5 201 (AUG) 2:1
High Voltage Engineering

Introduction to testing. condition monitoring and asset management of high voltage power apparatus. Generation and measurement of high ac. dc and impulse voltages in test laboratories. Generation and measurement of impulse current. Digital techniques in HV measurements. Calibration and traceability of

the measurements. Dry and wet tests. pollution test. RIV. corona. voltage distribution and composite stress testing. High current tests on surge arresters. Non-destructive insulation diagnostics. measurement of insulation resistance. Capacitance and tan δ . Partial discharges. DGA. Dielectric response analysis. SFRA. PDC and recovery voltage. Introduction to relevant national and international standards. Layout and clearances as well as shielding and grounding of HV lab. Safety regulations for high voltage tests.

Laboratory experiments on the above topics.

Joy Thomas M

Kuffel,E., Zaengl, W.S. and Kuffel, J.,High Voltage Engineering Fundamentals', Butterworth-Heineman press, Oxford, 2000.
Current literature from journals and conference proceedings.

E5 206 (JAN) 3:0
HV Power Apparatus

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

Udaya Kumar, L Satish and B S Rajanikanth

Bernard Hochart, Power Transformer Handbook, Butterworth, 1987.
The J & P Transformer Book, 12th Edn, M J 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 NY, 1996.
Flurscheim, C.H., Power Circuit Breaker: Theory and Design, Peter Peregrinus Ltd., 1975.
Ryan, H.M., and Jones G.R., SF6 Circuit Breaker, Peter Peregrinus Ltd., 1989.

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

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

L Satish

Ragaller, K. (ed.), Surges in High Voltage Networks, Plenum Press, 1980.
Transmission Line Reference Book, 345 kV and above EPRI, 1984.

E5 212 (JAN) 3:0
Computational Methods for Electrostatics

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

Udaya Kumar

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

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

Electrical power transmission by HVAC and HVDC, Overhead transmission lines, Bundled conductors, Mechanical vibration of conductors, Surface voltage gradient on conductors, Corona & associated power loss, Radio-noise and Audio-noise & their measurement, Fields under transmission lines, Overhead line insulators, Insulator performance in polluted environment, EHV cable transmission - underground cables and GIL, High Voltage substations-AIS and GIS, Grounding of towers and substations, Over voltages in power systems, Temporary, lightning and Switching over voltages, Design of line insulation for power frequency voltage, lightning and switching over voltages, Insulation Co-ordination.

Joy Thomas M

Begamudre R.D., Extra High Voltage AC Transmission Engineering –Wiley Eastern Limited, 1990
Transmission line Reference Book 345 kV & above, Electrical Power Research Institute, (EPRI), 1982 USA.
Journal Publications, Current literature from journals and conference proceedings.

E5 215 (AUG) 2:1
Pulsed Power Engineering

Overview of Pulsed Power Engineering, Energy storage devices, Pulsed power generators, Pulse transformers, Pulse modulators, PFN schemes, Marx circuits, Magnetic pulse compression, FCG, Explosively driven FCGs, Homopolar generators. Power conditioning systems, Switching devices, Insulation requirements for pulsed power systems- gaseous, liquid, solid and magnetic insulation and their behaviour under pulsed voltages. Measurement techniques of pulsed power parameters. Applications of pulsed power systems, pulsed power systems for high power lasers, HPM, UWB, IRA, Railgun, ETC, NEMP and ESD simulators. Pulsed power systems for biological and pollution control applications.
Laboratory experiments on the above topics

Joy Thomas M

Advances in Pulsed Power Technology, Vol. 1 & 2, Plenum Press, New York, 1987, 1990.
Current literature from journals and conference proceedings.

E5 231 (JAN) 2:1
Outdoor Insulation

Electric power transmission, AC & DC, overhead lines, air insulated substations, outdoor insulation functions, Types of line and station insulators up to 1200 kV, wall/equipment bushings, HVDC insulators, Materials used for outdoor insulation; porcelain, glass, synthetic/composite, wood, Types of stresses – electrical, mechanical, thermal, environmental, and extraneous and their implications, Aging mechanisms and failure modes, Deterioration of synthetic insulator due to UV rays and corona, Performance of Insulators in polluted/contaminated conditions and remedial measures, Field experience and standards employed for the evaluation, Maintenance and inspection of insulators in service, Computer simulation for estimation of electrical surface and bulk stress, lab experiments on insulator discs/strings for dry/wet (artificial rain) and polluted conditions, for both ac and dc high voltages.

Subba Reddy B and Udaya Kumar

Transmission Line Reference book 345 kV and above, EPRI, Palo Alto, USA, 1982
Ravi S Gorur, Edward Cherney and Jeffrey Burnham, “Outdoor Insulators”, text book, Phoenix, Arizona, USA 1999.
A Bradwell,
“Electrical Insulation”, text book, Peter Peregrinus Ltd, London, UK, 1983

E5 - 231(JAN) 2:1
OUTDOOR INSULATION

Electric power transmission, AC & DC, overhead lines, air insulated substations, outdoor insulation functions, Types of line and station insulators up to 1200 kV, wall/equipment bushings, HVDC insulators,

Materials used for outdoor insulation; porcelain, glass, synthetic/composite, wood, Types of stresses – electrical, mechanical, thermal, environmental, and extraneous and their implications, Aging mechanisms and failure modes, Deterioration of synthetic insulator due to UV rays and corona, Performance of Insulators in polluted/contaminated conditions and remedial measures, Field experience and standards employed for the evaluation, Maintenance and inspection of insulators in service, Computer simulation for estimation of electrical surface and bulk stress, lab experiments on insulator discs/strings for dry/wet (artificial rain) and polluted conditions, for both ac and dc high voltages.

Subba Reddy B & Udaya Kumar

Transmission Line Reference Book 345kV and above, EPRI, Palo Alto, USA, 1982.
Ravi S Gorur, Edward Cherney and Jeffrey Burnham, “Outdoor Insulators”, text book, Phoenix, Arizona, USA 1999.
A Bradwell, “Electrical Insulation”, text book, Peter Peregrinus Ltd, London, UK, 1983
T. J. Looms, Insulators for High Voltage, Peter Peregrinus Ltd., London, UK, 1988.
Brent Mills, "Porcelain Insulators & how they grew", text book, Leroy, NY, USA, 1970
Masoud Farzaneh and William Chisholm, "Insulators for Icing and polluted environments", text book, IEEE Press, A John Wiley & Sons, Inc, Publication 2009.
IEC Report Publication – 60815, “Guide for the selection of insulators in respect of polluted conditions”, 1986.
CIGRE Task force 33-04-01, “Polluted Insulators: A review of current knowledge”, 2000.
IEEE Std 4-1995, IEEE Standard "Techniques for High Voltage Testing", 1995.
Recent Journal/Conference and CIGRE publications.

E5-232 (May-June) Summer Term, 2:1
Advances in ELECTRIC POWER TRANSMISSION

Overview of primary and renewable energy sources, installed capacity and projected growth, recent advances in UHV power transmission, introduction to 765/1200kV AC and ±500/800 kV DC transmission systems; present status and future growth. Design criteria for overhead transmission lines: general system design, methodology, reliability, wind/ice loading, security and safety requirements, components of HV transmission systems, types of conductors/accessories, HTLS, bundle configurations, Transmission towers- calculations of clearances for power frequency, switching and lightning surges, right of way (ROW), earth wire/OPGW, selection of insulators for light, medium and heavy polluted areas, Up-gradation of existing transmission lines, Design considerations of UHV Substations, Comparison of AIS, Hybrid-AIS and GIS, review on insulation coordination/overvoltages for UHV systems, High performance metal oxide surge arresters, earthing and safety measures for 765/1200kV HV substations. Assignments involving computation of potential distribution, ground end electric and magnetic fields.

Subba Reddy B

Gilbert M. Masters, "Renewable and Efficient Electric Power Systems", John Wiley & Sons, Inc., Publication, 2004
Transmission Line Reference Book 345kV and above, EPRI, Palo Alto, USA, 1982.
Rakosh Das Begamudre, “ Extra High Voltage AC Transmission Engineering”, New Age International(P) Ltd, publishers, New Delhi, 2000.
E Kuffel, W S Zaengl and J Kuffel, “High Voltage Engg. Fundamentals”, textbook published by Butter worth- Heinemann (Newness publishers), second edition, 2000.
CIGRE Working Group SC B.3-22 “Technical requirements for substations exceeding 800 kV”, Brochure No: 400, Dec 2009.
Recent IEEE Journal/Conference and CIGRE publications.
IEC-60826, International standard, “Design criteria of overhead transmission lines”, 2003

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

Introduction to dielectrics and electrical insulation systems used in high voltage power apparatus: gaseous, vacuum, liquid, solid and composite insulation, behaviour of electrical insulation under electric stress, polarization, relaxation, permittivity and dielectric loss, space charge in dielectrics. Breakdown mechanisms under dc and 50 Hz ac voltages in gaseous insulation- ionization, attachment, Townsend and streamer theories, Paschen's law, partial breakdown, corona, time lags in breakdown, breakdown under impulse voltages, volt-time characteristics of breakdown, breakdown under high frequency voltages, breakdown in compressed gases, breakdown in vacuum, liquid, solid and composite insulation, polymers as dielectrics in various electrical equipments, polymer structure and morphology, classification of polymers, filled polymers for HV applications, introduction to nanodielectrics electrical degradation – treeing, partial discharge, tracking & erosion, stochastic models of breakdown, multistress ageing. Design of insulation systems used in various power apparatus (case studies) - transformers, bushings, circuit breakers, cables, capacitors, high voltage rotating machines, gas insulated substations and transmission lines, Computational dielectrics.
Laboratory experiments on the above topics.

Joy Thomas M

Kuffel,E., Zaengl,W.S. and Kuffel J.,High Voltage Engineering Fundamentals, Butterworth-Heineman press, Oxford, 2000 / Papers from IEEE Trans on Dielectrics and Electrical Insulation

E6 Electronic Power Drives

E6 201 (AUG) 2:1
Power Electronics

Overview; Power switching devices (BJT, MOSFET, IGBT); control and protection of power switching devices; electromagnetic elements and their design; choppers for dc to dc power conversion; single and multiquadrant operation of choppers; chopper controlled drives; closed loop control of drives.

G Narayanan

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

E6 202 (AUG) 2:1
Design of Power Converters

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

L Umanand

Mohan, Undeland and Robbins, Power Electronics: Converters, Applications and Design, John Wiley and Sons, 1989
Chryssis, G.C., High frequency switching power supplies, McGraw Hill 2nd Edition, 1989
Umanand, L., Power Electronics:Essentials and Applications, chapters 1 to 7, John Wiley, India, 2009.

E6 211 (JAN) 3:0
Electric Drives

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

G Narayanan

Ranganathan V.T., Electric Drives, Course Notes, IISc, 2005-06
Fitzgerald A.E., Kingsley C Jr. and Umans S.D., Electric Machinery, Tata McGraw Hill, 2003.
Leonhard W., Control of Electrical Drives, 3rd Edition, Springer
Miller T.J.E, Brushless Permanent-Magnet and Reluctance Motor Drives, Oxford Science Publications, 1989
Krishnan R., Permanent-Magnet-Synchronous and Brushless DC motor Drives, CRC Press, Taylor & Francis Group, 2010, Current Literature.

E6 212 (JAN) 3:0
Design and Control of Power Converters and Drives

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

K Gopakumar

Leonhard W., Control of Electrical Drives , Springer-Verlag, 1985
Mohan, Undeland and Robbins, Power Electronics : Converters, Application and Design, John Wiley and Sons, 1989
Krishnan, R., Electric Motor drives: Modelling, Analysis and Control, Prentice Hall, March 2001, Gopakumar K., Lecture notes

E6 221 (JAN) 3:0
Switched Mode Power Conversion

Switched mode power converters: Characteristics, constituent elements, operating principles, steady state analysis, stress and sizing of elements, control methods, duty ratio, current programmed, frequency programmed and sliding mode control, dynamic analysis and frequency domain models, design of feed back compensators, unity power factor rectifiers, resistor emulation principle and applications to rectifiers and active filters.

Vinod John

Ramanarayanan V., Switched Mode Power Conversion; Course Notes, CCE, IISc, 2004.
Robert Ericson, Fundamentals of Power Electronics, Chapman & Hall, 1997.
Issa Batarseh, Power Electronic Circuits, John Wiley, 2004.
Philip T krein, Elements of Power Electronics,Oxford Press, 1998.

E6 222 (JAN) 2:1
Design of Photovoltaic Systems

Introduction to photovoltaic energy conversion, Solar radiation and measurement, Solar cell and their characterization, Influence of insolation and temperature, Maximum power point tracking, Electrical storage with Batteries, controllers, DC power conditioning, AC power conditioners for grid connection, Solar power drives, Applications for pumping/refrigeration, Economic analysis of PV system, Energy analysis of PV system.

L Umanand

Chenming, H. and White, R.M., Solar Cells from B to Advanced Systems, McGraw Hill Book Co, 198: Ruschenbach, HS, Solar Cell Array Design Hand Varmostrand, Reinhold, NY, 1980.
Proceedings of IEEE Photovoltaics Specialists Conference. Solar Energy Journal.

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.

G Narayanan

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

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

phase locking, current control, DC bus control, power quality, unbalance, harmonics, surges, voltage and frequency windows.

Vinod John

IEEE papers and standards, datasheets, current literature.
Ramanarayanan V., Switched Mode Power Conversion, 2007.
Arthur R, Bergen, Vittal, Power Systems Analysis (2nd Ed) Prentice Hall, 1999.
Ned Mohan, Tore M, Undelnad, William P, Robbins (3 Edition), Power Electronics: Converters, Applications and Design; Wiley 2002.

E6 311 (JAN) 3:0
Selected Topics in Control of AC Motor Drives

Vector-control of induction and permanent magnet synchronous motor drives, self-commissioning, parameter adaptation, sensorless operation, direct self-control, advanced PWM schemes. slip ring induction motor drives, three level inverters.
A substantial portion of the course will consist of student seminars, simulation exercises and mini projects.

G Narayanan / Vinod John

Pre-requisites: E6 201 and E6 211

Leonhard. W., Control of Electric Drives, Springer Verlog, 1985.
Vas. P., Vector Control of AC Machines, Oxford University Press, 1990.
Current literature.

E7 Photonic Devices

E7 211 (JAN) 3:0
Photonics Integrated Circuits

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

T. SRINIVAS/T. BADRINARAYANA

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 of journals and review articles

E7 213 (AUG) 3:0
Introduction to Photonics

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

MANOJ VARMA / AMBARISH GHOSH

Bahaa Saleh and Malvin Teich, Fundamentals of Photonics, Wiley & Sons (1991)
Hecht E, *Optics.* Addison Wesley, 2001

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

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

T SRINIVAS/ ES SHIVALEELA

A. Selvarajan, S. Kar and T. Srinivas, Optical Fiber Communications, Principles and Systems, Tata – Mc Graw Hill, 2002.
G. Keiser, Optical Fiber Communications, 2nd Edition, McGraw Hill, 1991
I. P. Kaminov and T. L. Koch, Optical Fiber Telecommunications IIIA and IIIB, Academic Press, 1997.

E7 231 (JAN) 3:0

Fiber-Optic Networks

Introduction to Fiber-optic networks; Components for optical networks; Broadcast and select networks; Wavelength routing networks; Virtual topology design; Control and Management; Access networks; Deployment considerations; Photonics switching; Recent developments and futuristic issues.

T SRINIVAS / E S SHIVALEELA

Prerequisite: E7 221 or equivalent

R. Ramaswami and K. N. Sivarajan, Optical Networks: A practical Perspective, (2nd Ed), Morgan Kufmann Publishers 2002.
S. V. Kattalopoulos, Introduction to DWDM Technology, IEEE Press, 2000
Current literature: special issues of journals and review articles

E8 Electromagnetics, Microwaves and Antennas

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

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.

E8 202 (AUG) 2:1
Computational Electromagnetics

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

About the course
The course will have programming assignments (using Matlab/Fortran/C++).

DIPANJAN GOPE/K J VINOY

A. Taflove and SC Hagness Computational Electrodynamics: The Finite Difference Time Domain Method, 3ed 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. Harrington: Field Computation by Moment Methods, 1993, Wiley-IEEE Press

E8-242 (JAN) 2:1
Radio Frequency Integrated Circuits and Systems

Introduction to wireless systems, personal communication systems, High frequency effects in circuits and systems. Review of EM Fundamentals and Transmission line Theory, terminated transmission lines, smith chart, impedance matching, Microstrip and Coplanar waveguide implementations, microwave network analysis, ABCD parameters, S parameters. Behavior of passive IC components and networks, series and parallel RLC circuits, resonant structures using distributed transmission lines, components and interconnects at high frequencies Basics of high frequency amplifier design, biasing techniques, simultaneous tuning of 2 port circuits, noise and distortion.

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MEMS technologies and components for RF applications: RF MEMS switches, varactors, inductors and filters. Introduction to microwave antennas, definitions and basic principles of planar antennas. CRLH meta materials for microwave circuits and components.

Course will have Lab component involving design, fabrication and testing of some basic passive and active circuits with Industry Standard Softwares.

K. J. VINOY

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

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

Moore's law and its effect on interconnect technology: System level challenges; Signal Integrity (SI); Power Integrity (PI); Electromagnetic Interference (EMI); Heat Dissipation 2D Electrical Analysis for SI: RLGC extraction; Multiconductor transmission line method; Frequency and time domain simulation 2.5D Electrical Analysis for PI: Multilayered Finite Difference Method with gap and fringe corrections; Via Models 3D Electrical Analysis for SI, PI, EMI: Partial Element Equivalent Circuit Method; Simultaneous Switching Noise Fundamentals of: Crosstalk; Inter-symbol Interference; Reflection; Delay; Loss; Skin-effect; Proximity Effect; Channel Simulation: SPICE with S-parameters; Eye-diagram; Jitter; Pre-emphasis; Equalizer; 3D Thermal Analysis: Finite Difference Method; Heat sinks; Thermal vias; Thermal Interface MaterialRecent Trends: 3DICs; Through-silicon Vias

DIPANJAN GOPE

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

E9 Signal Processing

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.

K Rajgopal

Digital Signal Processing - Proakis and Manolakis - PHI.
Discrete-time Signal Processing - AV Oppenheim, RW Schafer, Prentice Hall 1998.
Digital Signal processing : A Computer-Based Approach – Sanjit K Mitra, Tata McGraw-Hill

E9 202 (JAN) 3:0
Advanced Digital Signal Processing : Non-linear Filters

Non-linear signal processing; non-linear filters. Non-Gaussian models, generalized Gaussian and stable distributions, robust estimation. Median smoothers, rank-order filters, weighted median smoother. 1 Threshold decomposition of signals, stacking property; positive Boolean function and stack filterting Introduction to order statistics, joint densities, momemts. Weighted median filtering. Mallows Theorem link between linear and non-linear smoothers and filters,. Generalized median/mean filtering : L-estimator; Lefilter, optimality. Myriad filtering. Non-linear filters based on Votterra series.

Faculty

Pre-requisite: E9-201 or equivalent.

G. R. Arce, Non-linear signal processing: A statistical approach, Wiley 2004.
J. Astola and P. Kuosmanen, Fundamentals of non-linear digital filtering, CRC Press, 1997.
V. John Mathews and G. L. Sicuranza, “Polynomial Signal Processing”, John-Wiley 2000.

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

Introduction to Compressed Sensing. Basic theory: l_1 minimization, null space property, necessary and sufficient conditions for $l_0 – l_1$ equivalence. Mutual coherence and the Restructed Isometry property, and their consequences. RIP and random matrices. Johnson-Lindenstrauss Lemma Stable signal recovery and the restricted eigenvalue property. Recovery algorithms and their performance guarantees. Special/advanced topics upon student request.

CHANDRA R. MURTHY

Pre-requisite: Random Processes, Matrix Theory

M. Elad, “Sparse and Redundant Representations”, Sprinter, 2010.
H. Rauhut, “Compressive Sensing and Structured Random Matrices,” Radon Series Comp. Appl. Math., 2011.
R. Baranuik, M. A. Davenport, M. F. Duarte, C. Hegde, “An Introduction to Compressive Sensing,” Rice University Connextions Course, 2011.

E9 211 (JAN) 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.

K Rajgopal

Ali H Sayed, Adaptive Filters, John Wiley/IEEE, 2008.

E9 212 (JAN) 3:0
Spectrum Analysis

Estimation of PSD from finite data: Nonparametric methods: - Periodogram, Properties, Bias and Variance analysis - BT method, Window design considerations, Time-Bandwidth Product and Resolution-variance tradeoffs in window design - Modified Periodogram methods: Bartlett, Welch. Parametric methods for Rational Spectra: - Covariance properties of AR, MA, ARMA processes - Yule-Walker method, Levinson-Durbin algorithm - Multivariate ARMA processes: State-space representation, subspace parameter estimation. Parametric methods for line spectra (sinusoids in noise) -Models of sinusoids in noise - Higher-order YW method, Pisarenko, MUSIC, ESPRIT, Prony methods. Formulation of the Spatial spectrum problem. Introduction to Higher-Order Spectra

K V S HARI

Matlab based assignments.
Ref: Introduction to Spectral Analysis by Stoica and Moses, PH 1997.

E9 213 (JAN) 3:0
Time-Frequency Analysis

Time-frequency distributions: temporal and spectral representations of signals, instantaneous frequency, Gabor's analytic signal, the Hilbert and fractional Hilbert transforms, Heisenberg's uncertainty principle, densities and characteristic functions, global averages and local averages, the short-time Fourier transform (STFT), filterbank interpretation of STFT, the Wigner distribution and its derivatives, Cohen's class of distributions (kernel method), bilinear time-frequency distributions, Wigner's theorem, multicomponent signals, instantaneous bandwidth, positive distributions satisfying the marginals, Gabor transform *Spaces and bases:* Hilbert space, Banach space, orthogonal bases, orthonormal bases, Riesz bases, biorthogonal bases, Frames, shift-invariant spaces, Shannon sampling theorem, B-splines.
Wavelets: Wavelet transform, real wavelets, analytic wavelets, dyadic wavelet transform, wavelet bases, multi resolution analysis, two-scale equation, conjugate mirror filters, vanishing moments, regularity, Lipschitz regularity, Fix-Strang conditions, compact support, Shannon, Meyer, Haar and Battle-Lemarié wavelets, Daubechies wavelets, relationship between wavelets and filterbanks, perfect reconstruction filterbanks.

Chandra Sekhar S / Prasanta Ghosh

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

E9 221 (AUG) 3:0
Signal Quantization and Compression

Speech, music, image, video, biomedical signals: waveform and model based compression; Lossless and lossy. Quantization: optimum Lloyd-Max algorithm, companding and adaptive quantization; Linear

prediction: optimum prediction – open loop Vs closed loop, adaptive prediction, 2D prediction for image/video; oversampling: delta modulation, adaptive delta-modulation, sigma-delta modulation; transform coding: orthogonal transforms, optimum bit allocation, perceptual bit-allocation; vector quantization: generalized Lloyd-Max algorithm, generalized distance measures, structured VQ: tree-structured VQ, multi-stage VQ, product-VQ; sub-band coding: perfect reconstruction filter-banks, QMF.

T V Sreenivas

N. S. Jayant and P. Noill, Digital Coding of Waveforms-Principles and Application to Speech and Video, Prentice Hall, 1984.
A. Gersho and R. Gray, Vector Quantifisation and Signal Compression, Kluwer Acad Publication, 1992.
L. Hanzo, F. C. A. Somernille and J P Woodard, Voice Compression and Communication, John Wiley, 2001.

E9 231 (AUG) 3:0
Digital Array Signal Processing

Wave Fields, underlying wave equations, scalar and vector fields, spectral representation, propagation in open and confined media. Sensor array systems: Linear equispaced, circular, planar, random arrays. Direction of arrival estimation: Source waveform estimation. Beam forming, Subspace Methods (MUSIC, ESPRIT), Spatial Smoothing, Performance Analysis. Applications to acoustic source separation and wireless communication.

K V S HARI

Johnson & Dudgeon, “Array Signal Processing Concepts & techniques”, Prentice Hall 1993.
P S Naidu, “Sensor Array Signal Processing”, C R C Press 1999.
Lecture notes and current literature

E9 241 (AUG) 2:1
Digital Image Processing

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

Chandra Sekhar Seelamantula

Lim J. S., Two-dimensional signal and image processing, Prentice Hall, 1990.
Jain A. K., Fundamentals of digital image processing, Prentice Hall, 1989.
Gonzalez R. C. and Woods R. E., Digital image processing, Prentice Hall, 2008.
Dudgeon D.E. and Merserau R. M., Multidimensional digital signal processing, Prentice Hall Signal Processing Series, 1983.

E9 242 (AUG) 3:0
Selected Topics in Image Processing

Image segmentation and clustering: mean-shift, graph cut. Image pyramids and texture analysis. Linear/non l linear scale space theory: Scale Invariant Feature Transform (SIFT). Visual tracking: mean-shift, particle filters, feature-based. Background modeling, surveillance and monitoring: event detection/recognition. Face detection and recognition, motion analysis and segmentation, graphical models, Markov random fields and applications. Basics of 3-D vision.

K R Ramakrishnan

Forsyth, A.A., and Ponce, J., Computer Vision: A Modern Approach, Pearson Education, 2003
Paragios, N., Chen, Y., and Faugeras, O. (Eds), Handbook of Mathematical Models in Computer Vision, Springer, 2006.
Bishop, C.M., Pattern Recognition and Machine Learning, Springer, 2006.

E9 243 (JAN) 3:0
Computer Aided Tomographic Imaging

Introduction to principles of tomography and applications, tomographic imaging. Radon transform and its properties, mathematical framework. Introduction to X-ray tomography, emission computer tomography, magnetic resonance imaging systems. Projection and Fourier slice theorem. Scanning geometries: translate and rotate, translate-rotate, rotate on a circular trajectory for 2-D imaging and helical or spiral scan trajectory for 3-D imaging. Transform domain algorithms: Fourier inversion algorithms, filtered back projection algorithms – reconstruction with non-diffracting sources, parallel projections and fan projections for 2-D and cone beam projections on circular and spiral trajectory for 3-D reconstruction. Computer implementation, iterative reconstruction techniques: algebraic reconstruction techniques, statistical modeling of generation, transmission and detection processes in X-Ray CT, artifacts and noise in CT images. Image reconstruction with incomplete and noisy data, applications of Radon transform in 2-D Signal and Image processing.

K Rajgopal

Kak, A.C., and Slaney, M., Principles of Computerized Tomographic Imaging, IEEE Press, 1988.
Herman, G.T., Image Reconstruction from Projections, Implementation and Applications: Topics in Applied Physics, Vol 32, Springer Verlag, 1979.
Natterer, F., The Mathematics of Computerized Tomography, SIAM Classics In Applied Mathematics, Vol. 32, 2001.
Natterer, F., and Wubbeling, F., Mathematical Tools in Image Reconstruction, SIAM, 2001.

E9 244 (AUG) 2:1
Document Analysis and Recognition

Document images – printed, handwritten, camera captured, text in scenic images. Layout analysis, Text localization and extraction from complex colour images. Binarization of colour images, Segmentation of images, graphic items, signatures. Script, orientation, language and font identification, optical character recognition, common features, Skew detection and correction, holistic word recognition. Alignment of curved text, offline and online handwriting recognition, context based postprocessing, verification. Annotated databases. Analysis of Degraded Documents. document image compression. Test and calibration charts. Applications – postal automation, forms processing,digital libraries, digital books for the blind, field extraction from legal documents, translation of text from boards, signs, etc., conversion of ancient manuscripts, bank cheque processing, document authentication.

A G Ramakrishnan

Prerequisites: E1 213 E1 216 / E9 241or Consent of the instructor.

Current Literature.
Guide to OCR for Indic Scripts: Document Recognition and Retrieval. Springer, Dec. 2009. Ed: Venu Govindaraju and Setlur Srirangaraj.
Cheriet M, Kharma N, Liu C L and Suen C Y. Character recognition systems: A guide for students and practitioners, John Wiley & Sons, 2007.
Nagy G., "Twenty Years of Document Image Analysis in PAMI," IEEE Trans Pattern Analysis Machine Intelligence. vol. 22, pp. 38-62, Jan 2000.

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.

Venu Madhav Govindu

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

Hartley, R., and Zisserman, A., Multiple View Geometry in Computer Vision, Second Edn, Cambridge University Press, 2004.
Faugeras, O., and Luong, Q-T.,The Geometry of Multiple Images, MIT Press 2001.
Current literature

E9 251 (AUG) 3:0
Signal Processing for Data Recording Channels

Introduction: Review of basic principles behind the physics of magnetic recording, super paramagnetic limits, technological trends in magnetic storage/optical systems, recording schemes in magnetic and optical devices. Signal Modeling: Communication theoretic framework of read/write channels. Models for analog read back signal with inter-symbol interference, noise and distortion sources, notion of channel and user bit densities towards SNR definition. Signal Processing Methods: Equalization and timing recovery, PLLs, ML based timing recovery methods, Detection techniques based on the BCJR algorithm and its low complexity variations, turbo-equalization methods. Coding Techniques: Introduction to constrained modulation codes, review of algebraic and graphical coding techniques, interleaving mechanisms and analysis of the code performance. Implementation: Hardware related aspects for realizing signal processing algorithms on a system-on-chip (SoC).

Shayan Srinivasa Garani

Bergmans, J.W.M., Digital Baseband Transmission and Recording, Kluwer Academic Press, 1996
Vasic, B., and Kurtas, E., Coding and Signal Processing for Magnetic Recording Systems, CRC Press, 2004.

E9 252 (AUG) 3:0
Mathematical methods and techniques in signal processing

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

Shayan Srinivasa Garani

Moon & Stirling, *Mathematical Methods and Algorithms for Signal Processing*, Prentice Hall, 2000. (required)
Monson Hayes, *Statistical Digital Signal Processing and Modeling*, John Wiley and Sons, 1996. (optional)
Class notes

E9 261 (AUG) 3:1
Speech Information Processing

Overview of speech communication: speech production/perception/linguistics; Applications: speech coding, speech synthesis, speech recognition and speech enhancement.

Time-varying signal analysis: short-time Fourier transform, Gabor transform, speech spectrograms; Quasi-stationary analysis: cepstrum linear-prediction (AR) and ARMA models; Time-varying models: time-varying linear-precition; Sinusoidal models: quasi-stationary analysis, chrip signal analysis; Binaural signal modeling, source localization; Auditory models.

T V SREENIVAS

"Speech Science Primer", by G. J. Borden and K. S. Harris, Williams and Wilkins, 1984
"Discrete-time speech signal processing", by T. F. Quatieri, Prentice-Hall, 2002.
"The Speech Chain: Physics & Biology of spoken language", by P. B. Denes and E. N. Pinson, W. H. Freeman, 1983.

E9 271 (JAN) 3:0
Space-Time Signal Processing and Coding

Brief review of single-input single-output (SISO) communication systems. Performance of SISO systems in fading channels. Motivation for Space-Time (or Multiple-Input Multiple-Output (MIMO) communication systems. Capacity of MIMO systems. Space-Time codes: Space-Time Trellis codes and Space-Time Block codes; Design Criteria for code constructions; Constructions using Orthogonal designs and their variations; Algebraic techniques for space-time codes; Decoding algorithms for Space-Time Codes. Distributed Space Time Coding.

B SUNDAR RAJAN

Pre requisites: Digital Communication
Current literature

E9 262 (JAN) 3:0
Stochstic Models for Speech/Audio

Human speech communication, concept=> signal=> concept & levels of information. Discrete and continuous representations, pattern representation of signals; structure representation through lexicon, grammar. ASR: text recognition, speaker recognition, language identification, keyword spotting. Gaussian models and Bayesian inference; maximum likelihood parameter estimation. Mixture Gaussian models, EM algorithm, relation to K-means algorithm, LBG algorithm and EM generalization. Application to speaker-ID. Units of speech: linguistic, acoustic and stochastic; segmentation problem. Dynamic programming and maximum-likelihood segmentation; segment clustering and automatic sub-word units. Graphical models and Markov models; Language modeling, N-grams and their estimation. Tree structured language model, minimum entropy decision tree algorithm; language perplexity measure. Application to spoken language-ID. Hidden Markov model (HMM): Markov structure for latent variables; Gaussian density, discrete density, mixture Gaussian and semi-continuous density models. HMM evaluation, training and decoding problems: forward-backward algorithm, Baum-Welch algorithm, Viterbi algorithm, segmental K-means (SKM) algorithm. HMM duration density and explicit duration modeling and modified EM algorithm. Finite state network (FSN) of HMMs and lexicon building. Continuous speech recognition (CSR) through FSN decoding using time-synchronous Viterbi algorithm. Viterbi beam search for low complexity. Latent semantic analysis (LSA) of text and discrete sequences.

T. V. SREENIVAS

Pre-requisite: E2-202 Random Processes or equivalent.

* X. Huang and A. Acero and H. Hon: "S poken Language Processing," Prentice Hall, 2001
+ Research papers
* C.M. Bishop: "Pattern Recognition and Machine laearning," S pringer, 2006.
* L.R. Rabiner and B.H. Juang: "Fundamentals of speech recognition," Prentic e Hall, 1993.

E9 283 (JAN) 3:0
Medical Imaging Systems and Applications

Historical perspective, Generic principles - modality, contrast, SNR, resolution. X-ray projection radiography, Computerized Tomography (CT) - acquisition and reconstruction methods, applications. Nuclear medicine - planer scintigraphy, PET, SPECT imaging. Ultrasound imaging - imaging modes, transducers, beam forming. Magnetic resonance imaging - Physics, data acquisition, image

reconstruction. Biomedical optical imaging – introduction to optical imaging, microscopy, diffuse optical imaging, optical coherence tomography, photoacoustic imaging.

Manojit Pramanik

Prerequisites: Consent from the Instructor.

Albert Macovski, Medical Imaging Systems, Prentice Hall, 1983.
Jerry L. Prince and Jonathan M. Links, Medical Imaging Signals and Systems, Prentice Hall, 2005.
L. V. Wang and H.-i Wu, Biomedical Optics: Principles and Imaging,Wiley, 2007.

E9 284 (JAN) 3:0
Biomedical Optical Imaging and Spectroscopy

Topics: A brief introduction to medical imaging, basic principles of imaging modalities such as x-ray, CT, SPECT, PET, MRI, Ultrasound, introduction to biomedical optics, single-scatterer theories, Monte Carlo modeling of photon transport, convolution for broad-beam responses, radiative transfer equation and diffusion theory, hybrid model of Monte Carlo and diffusion theory, sensing of optical properties and spectroscopy, optical coherence tomography, diffuse optical tomography, photoacoustic and thermoacoustic tomography, ultrasound modulated optical tomography.

Manojit Pramanik

Prerequisites: Consent from the Instructor.
L. V. Wang and H.-i Wu, Biomedical Optics: Principles and Imaging (Wiley, 2007). ISBN: 978-0-471-74304-0.
V. Tuchin, "Tissue Optics," 2007, SPIE Press

E9 285 (JAN) 3:0
Biomedical Imaging- Inverse Problems

Overview of linear imaging modalities: Gaussian and Poisson noise in imaging devices; Image formation in microscopy, tomography, and magnetic resonance imaging; reconstruction as regularized inversion. Regularized reconstruction from noisy measurements: Regularization for noise-stabilized inversion; L2 (quadratic) regularization; L1 regularization; half-quadratic regularization; Superiority of L1 and half-quadratic regularizations over L2 regularization; Optimization algorithms for L1 and half-quadratic regularized inversion of different imaging modalities. Regularized reconstruction from reduced measurements: The notion of sparsity in images; L1 regularization for enforcing sparsity; compressed sensing and sparse image reconstruction; Overview of successful compressed sensing methods.

Muthuvel Arigovindan

Prerequisites: Digital signal processing, and Linear algebra.
Representative papers from the literature.

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 TI 6x and Beagle boards.

G N Rathna

Rulph Chassaing, Digital signal processing and applications with C6713 and C6416 DSK, Wiley, 2005

Keshab K. Parhi, VLSI Digital Signal Processing Systems:Design and Implementation, student Edition, Wiley, 1999.
Nasser Kehtarnavaz, Digital Signal Processing System Design: LabVIEW-Based Hybrid Programming, Academic Press, 2008
Current Literature.

E9 292 (JAN) 2:1
Real Time Signal Processing

Real Time implementation of Digital Signal and Image processing algorithms using Java DSP, TMS320C6x DSK kit , LabVIEW and crossbow Sensor motes.

K Rajgopal / G N Rathna

Pre-requisite: Knowledge of Digital Signal Processing
Real–Time Digital Signal Processing based on TMS320C6000, Nasser Kehtarnawaz, Elsevier, 2004
Digital Signal Processing System Design:LabVIEW-Based Hybrid Programming, Nasser Kehtarnavaz, Academic Press, 2008
Materials from webpages

EP Dissertation Project

EP 299 0:28
Project

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

FACULTY

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, Earth Sciences, Mechanical Engineering, Management Studies, Materials Engineering, Product Design and Manufacturing and Sustainable Technologies and Integrated Centre for Energy Research. It also administer an Institute facility, 'Advanced Facility for Microscopy and Microanalysis'. The courses offered in the different departments of the Division have been reorganized after review and revision, and have been grouped department wise. These are identified by the following code.

AE	Aerospace Engineering
AS	Atmospheric and Oceanic Sciences
CE	Civil Engineering
CH	Chemical Engineering
ER	Energy Research
ME	Mechanical Engineering
MG	Management Studies
MT	Materials Engineering
PD	Product Design and Manufacturing
ST	Sustainable Technologies

The first two digits of the course number have the departmental code as the prefix. All the Departments/Centres (except the Space Technology Cell) of the Division provide facilities for research work leading to the degrees of MSc (Engg.) 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. M E Degree Programmes are offered in Aerospace Engineering, Civil Engineering, Chemical Engineering, Materials Engineering and Mechanical Engineering. M Des is offered in the Centre for Product Design and Manufacturing. M Tech Programme in Atmospheric and Oceanic Sciences, Department of Civil Engg and CiSTUP jointly offers an M Tech Programme in Transportation Engineering. Department of Management Studies offers Master of Management. Most of the courses are offered by the faculty members of the Division, but in certain areas, instruction by specialists in the field and experts from industries are also arranged.

Prof. K Chattopadhyay
Chairman
Division of Mechanical Sciences

Aerospace Engineering

ME Programme
Duration: 2 years
64 Credits

Hard Core: 24 Credits

AE 203 3:0	Fluid Dynamics
AE 220 3:0	Flight and Space Mechanics
AE 221 3:0	Flight Vehicle Structures
AE 245 3:0	Mechanics and Thermodynamics of Propulsion
AE 259 3:0	Navigation, Guidance and Control
AE 271 1:2	Flight Vehicle Design
AE 276 1:2	Experimental Techniques
AE 211 3:0	Mathematics for Aerospace Engineers

In place of AE 211, any Mathematics course of 3 credits approved by DCC may be taken

Project: 19 Credits

AE 299 0:19 Dissertation Project

Electives: A balance of 21 credits is required to make up a minimum of 64 credits. A minimum of two courses in Aerodynamics/Guidance and Control/ Propulsion/ Structure needs to be taken from the departmental courses listed below. This leaves approximately 12 credits to be taken from electives within/ outside the department.

AE 202 (JAN) 3:0
Atmospheric Flight Dynamics

Review of equations of motion, stability, derivative estimation, static stability and control, longitudinal and lateral modes, transfer function and response characteristics, feedback and automatic control, response to atmospheric gust and turbulence. Handing qualities, human pilot modeling case studies of typical airplanes, roll and spin characteristics, flight simulators, stability and control derivative estimation from wind tunnel and flight tests.

Dineshkumar Harursampath

Elkin, B. & Reid, L.D., Dynamics of Flight: Stability & Control, John Wiley and Sons, 3rd Edition, 1996

AE 203 (AUG) 3:0
Fluid Dynamics

Properties of fluids, characteristics of the atmosphere, motion of a fluid element, conservation laws of mass, momentum and energy, inviscid flows, potential flows, vortex motion, aerodynamics of airfoils, boundary layer transition and turbulent flows.

Joseph Mathew, O N Ramesh, Arnab Samanta

Gupta, V., and Gupta, S.K., Fluid Mechanics and its Applications, Wiley Eastern, 1984.
Fay, J.A., Introduction of Fluid Mechanics, Prentice Hall of India, 1996.
Kuethe, A.M., and Chou, S.H., Foundations of Aerodynamics Wiley, 1972.

AE 204 (JAN) 3:0
Aerodynamics

Introduction to small perturbation theory, 2-D airfoils in subsonic and supersonic flow, numerical methods for 2-D airfoils, similarity rules, Multhop's method, vortex lattice and double lattice methods, effects of sweep and AR, aerodynamics of wing-fuselage system and aerodynamics of control surfaces. High angle of attack aerodynamics, non-linear aerodynamics, unsteady aerodynamics.

O N Ramesh and N Balakrishnan

Pre-requisite: AE 203

Houghton, E.L., and Basewell, R.P., Further Aerodynamics for Engineers, Edward Arnold Publishing Company.
Holt Ashley and Landhall, M., Aerodynamics of Wings and Bodies, Addison-Wesley, 1965
Jones, R.T., Wing Theory, Princeton University Press, 1990.

AE 206 (AUG) 3:0
Hypersonic Flow Theory

Characteristic features of hypersonic flow, basic equations boundary conditions for inviscid flow, shock shapes over bodies, flow over flat plate, flow over a wedge, hypersonic approximations, Prandtl-Meyer flow, axisymmetric flow over a cone. Hypersonic small disturbance theory, applications to flow over a wedge and a cone, blast wave analogy, Newtonian impact theory, Busemann centrifugal correction and shock expansion method, tangent cone and tangent wedge methods. Introduction to viscous flows, hypersonic

boundary layers, non-equilibrium high enthalpy flows. High enthalpy impulse test facilities and instrumentation. Computational fluid mechanics techniques for hypersonic flows, methods of generating experimental data for numerical code validation at hypersonic Mach numbers in hypervelocity facilities.

K P J Reddy and G Jagadeesh

Pre-requisite: AE 204, AE 210

Cherynl, C.G., Introduction to Hypersonic flow, Academic Press, 1961.
Hayes, W.D., and Problein, R.F., Hypersonic Flow Theory, Academic Press, 1959.
Cox, R.N., and Crabtree, L.P., Elements of Hypersonic Aerodynamics, London, 1965.

AE 207 (JAN) 3:0
Hypersonic Aerothermodynamics

Hypersonic aerodynamics, shock waves and basic properties of gases, characteristic features of hypersonic flows, equations of motion of equilibrium and non-equilibrium flows. Transport properties of gases, definition and techniques of estimation of aero-thermodynamic environments including CFD, ground based test facilities for hypersonic flow- field measurements including heat transfer and aerodynamic forces, analysis of stagnation region flow-field and pressure distribution over hypersonic flight vehicles. Viscous interactions, aerothermodynamics and design considerations of hypersonic reentry vehicles.

K P J Reddy

Pre-requisite: AE 206

John J Bertin, Hypersonic Aerothermodynamics, AIAA Education Series, 1994.

AE 209 (AUG) 3:0
Aerodynamic Testing Facilities and Measurements

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

B Vasudevan

William H Roe Jr., and Alan Pope, Low Speed Wind Tunnel Testing Wiley and Sons, 1984.
Pankhrust, R.C., and Holder, D.W., Wind-Tunnel technique, Sir Isaac Sons Ltd., London, 1968.
Lukasiewicz, J., Experimental methods of Hypersonic, Marcel Dekker in New York, 1973.
Alan Pope and Kenneth L Going, High-Speed Wind Tunnel Testing, Wiley and Sons, 1965.

AE 210 (JAN) 3:0
Gas Dynamics

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

G Jagadeesh or Joseph Mathew

Pre-requisite: AE 203

Liepmann, H.W., and Roshko, A., Elements of Gas Dynamics, John Wiley, 1957.
Becker, E., Gas Dynamics Academic Press, New York, 1968.
John D Anderson, Modern Compressible Flow, McGraw Hill, 1990.

AE 211 (AUG) 3:0
Mathematics for Aerospace Engineers

Real Analysis: series and sequences, limits, continuity and derivatives of functions, closed and open sets, compactness, metric spaces, uniform convergence. Convex Analysis: algebra of convex sets, convex functions and their properties. Linear Algebra: algebraic structures, vector spaces, linear transformations, canonical forms, solution of linear systems of equations, techniques for eigen value extraction, iterative solvers. Introduction to variational calculus: weighted residual technique, numerical integration, integral transforms, solution of differential and partial differential equations using integral transforms. Introduction to Partial Differential Equations (PDE), linear convection (first order wave) equation, method of characteristics. Non-linear convection equation (Burger's equation): discontinuous solutions and expansion waves, Riemann problem, hyperbolic systems of PDEs, parabolic PDEs, elliptic PDEs.

S V Raghurama Rao, S Gopalakrishnan and D Ghose

David Logan, J., An Introduction to Nonlinear PDEs, 2nd edition, Wiley Interscience.
Courant, R., and Hilbert, D., Methods of Mathematical Physics, Wiley-VCH.
Gilbert Strang, Introduction to Applied Mathematics, Wellesley Cambridge Press.

AE 214 (JAN) 3:0
Turbulent Shear Flows

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

O N Ramesh

Tritton, D.J., Physical Fluid Dynamics, Oxford University Press.
Tennekes, H., and Lumley, J., A first course in turbulence, M.I.T. Press.
Townsend, A.A., The structure of turbulent shear flow, Cambridge Univ. Press.

AE 216 (JAN) 3:0
Numerical Fluid Flow

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

N Balakrishnan

Charles Hirch, Numerical Computation of internal and external flows, Vol.1&2, Wiley-Interscience publication, 1990.

AE 217 (AUG) 2:1
Computation of Viscous flows

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

N Balakrishnan

Pre-requisite: AE 216

Recent literature

AE 218 (JAN) 3:0
Computational Gas Dynamics

Governing equations of compressible fluid flows, classification of partial differential equations, analysis of hyperbolic conservation laws, basics of discretization, finite difference and finite volume methods, numerical diffusion, numerical methods for scalar and vector conservation laws, central and upwind discretization methods, flux splitting methods, Riemann solvers, kinetic (Boltzmann) schemes, relaxation schemes.

S V Raghurama Rao

Pre-requisites: AE 203, AE 210, Numerical Analysis/ Numerical Methods and any programming language.

Laney, B., Computational Gas Dynamics.
Toro, E.F., Riemann Solvers and Numerical Methods for Fluid Dynamics.

Godlewski, E., and Raviart, P., Numerical Approximation of Hyperbolic System of Conservation Laws.

AE 219 (JAN) 3:0
Numerical Grid Generation and Flow Computations

Basics of fluid dynamics, gas dynamics, governing equations of fluid dynamics, various levels of approximation, partial differential equations, basics of discretization, finite difference, finite volume methods, mesh-less methods, space marching and time marching approaches, geometrical complexities for mesh generation, methods of mesh generation, examples of simple flow computations.

Prakash S Kulkarni

Tannehill, J.C., Anderson, D.A., and Pletcher, R.H., Computational Fluid Mechanics and Heat Transfer.
Anderson, Computational Fluid Dynamics—Basics and applications.
Joe Thompson, Numerical Grid Generation.

AE 220 (AUG) 3:0
Flight and Space Mechanics

Pioneers in aerospace history, basics of flight; airflow in standard atmosphere. Airplane aerodynamics–airfoils and finite lifting surfaces, thrust, power, level flight gliding, take-off, landing and basic manouvres. Airplane performance, stability and control, mechanics of launch vehicles and satellites. Introduction to aerospace design, structural components and engine options. Glimpses of new technologies like unmanned, micro aerial and hypersonic vehicles.

Ranjan Ganguli and S N Omkar

Anderson, J.D. Jr., Introduction to Flight, Fifth Edition, McGraw Hill Higher Education 2007.
Barnard, R.H., Philpott, D.R., and Kermode, A.C., Mechanics of Flight, Eleventh Edition, Prentice Hall 2006.

AE 221 (AUG) 3:0
Flight Vehicle Structures

Characteristics of aircraft structures and materials, introduction to elasticity, torsion, bending and flexural shear, flexural shear flow in thin-walled sections, elastic bucking, failure theories. Variational principles and energy methods, analysis of composite laminates, loads on aircraft, basic aeroelasticity.

Kartik Venkatraman, D Roy Mahapatra, Dineshkumar Harursampath and Suhasini Gururaja

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, 1999.
Wallerstein, D.V., Variational Approach to Structural Analysis, John Wiley and Sons, 2001.
Shames, I.H., and Dym, C.L., Energy and Finite Element Methods in Structural Mechanics, Taylor and Francis, 1991.

AE 223 (JAN) 3:0
Energy and Finite Element Methods

Introduction to Energy Methods; Principle of Virtual Work, Principle of Minimum Potential Energy, Raleigh Ritz Method, Hamilton's Principle. Introduction to Variational Methods, Weak form of Governing Equation, Weighted residual method, Introduction to Finite elements, and Galerkin Finite elements. Finite Element Method - Various element formulations for metallic and composite structures, isoparametric element formulation, Numerical Integration, concept of consistency, completeness and mesh locking problems. Finite element methods for structural dynamics and wave propagation, Mass and damping matrix formulation, Response estimation through modal methods, direct time integration, Implicit and Explicit Methods. Introduction to super convergent finite element formulation and spectral finite elements.

S Gopalakrishnan

Prerequisite: AE 221/ME 242/ CE 214 and knowledge of MATLAB

Cook, R.D., Malkus, D.S., and Plesha, M.E., Finite Element Analysis, John Wiley & Sons, New York, 1995.
Bathe, K.J., Finite Element Procedures, Prentice Hall, New York, 1996.
Varadan, V.K., Vinoy, K.J., and Gopalakrishnan, S., Smart Material Systems and MEMS, John Wiley & Sons, UK, 2006.
Gopalakrishnan, S., Chakraborty, A., and Roy Mahapatra, D., Spectral Finite Elements, Springer Verlag, UK, 2008.

AE 224 (AUG/JAN) 3:0
Analysis and Design of Composite Structures

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

Dineshkumar Harursampath, G Narayana Naik and Suhasini Gururaja

Gibson, R.F., Principles of Composite Material Mechanics, CRC Press, 2nd Edition, 2007.
Jones, R.M., Mechanics of Composite Materials, 2nd Edition, Taylor & Francis, 2010 (Indian Print).
Daniel, I.M., and Ishai O., Engineering Mechanics of Composite Materials, Oxford University Press, 2nd Edition, 2005.
Reddy, J.N., Mechanics of Laminated Composite Plates and Shells – Theory and Analysis, CRC Press, 2nd Edition, 2004.

AE 225 (AUG) 3:0
STRUCTURAL DYNAMICS

Vibration of discrete systems: Variational approach to derive the equations of motion (EOM), equilibrium points and linearization about the equilibrium points, forced response due to arbitrary excitations (Duhamel/convolution integral), multi degree of freedom system, modal analysis and decoupling of EOM.*Vibration of continuous systems:* Vibration of strings, bars, beams (Rayleigh beams, Euler-Bernoulli beams and Timoshenko beams), membranes. Variational approach to derive the EOM, modal analysis,orthogonality conditions, expansion theorem, initial and boundary value problems, forced response of systems, D'Alambert's wave solution, solution by Green's function approach, approximate methods (Ritz method, Rayleigh-Ritz method, Rayleigh quotient, Galerkin's method).

K. R. Jayaprakash / S. Gopalakrishnan

L. Meirovitch, 'Analytical Methods inVibrations', MacMillan, 1967
S. S. Rao, 'Vibration of Continuous Systems', John Wiley, 2007
P. Hagedorn, A. Dasgupta, 'Vibration and Waves in Continuous Mechanical Systems', John Wiley, 2007
F. S. Tse, I. E. Morse, R. T. Hinkle, 'Mechanical Vibrations Theory and Applications', CBS Publishers, 2002

AE 227 (AUG) 3:0
Multi-Body Dynamics using Symbolic Manipulators

Computer-aided modeling and simulation of 3D motions of multi-body systems. Coupled, multi-body kinematics and dynamics, reference frames, vector differentiation, configuration and motion constraints, holonomicity, generalized speeds, partial velocities and partial angular velocities, Rodrigues parameter, inertia dyadics, parallel axes theorems, angular momentum, generalized forces, energy integrals, momentum integrals, generalized impulses and momentum, exact closed – form and approximate numerical solutions. Comparing Newton/Euler's, Lagrange's and Kane's methods. Generation and solution of equations of motion using computer algorithms and software packages from amongst MotionGenesis™ Kane, AUTOLEV™ MATHAMATICA® and MATLAB®. Overview of flexible multi-body dynamics and applications in aerospace vehicular dynamics.

Dinesh K Harursampath

Kane, T., and Levinson, D., Dynamics Online: Theory and implementation with AUTOLEV™. Online Dynamics Inc., Sunnyvale, CA, USA, 2000.
Mitiguy, P. Advanced Dynamics and Motion Simulation, MotionGenesis, San Mateo, CA, USA, 2008.
Wolfram, S., The Mathematica® book, Cambridge University Press, 5th Edition, 2003.

AE 228 (AUG/JAN) 3:0
Fatigue and Failure of Materials

Fatigue and damage tolerance in aerospace structures. Fatigue mechanism (macro and micro aspects), fatigue properties and strength, concept of stress concentration factor, effect of residual stresses, total-life approaches (stress-life, strain-life, fracture mechanics), effect of notches, constant and variable amplitude loading (cycle counting, damage summation, etc), multi-axial fatigue theories. Special topics on fatigue in composites will also be covered.

Suhasini Gururaja

S. Suresh, Fatigue of Materials, Cambridge University Press, 1991
J.Schijve, Fatigue of Structures and Materials, Kluwer Academic Publ 2001
T.L .Anderson, Fracture Mechanics: Fundamentals and Applications, 3rd Edition, CRC Press 2005.
Current Literature.

AE 230 (JAN) 3:0
Aeroelasticity

Static aeroelasticity, bending - torsion flutter of a wing, dynamic response of a wing to gust and atmospheric turbulence, flutter identification, aeroelastic control.

Kartik Venkatraman

Pre-requisite: An understanding of mechanics.

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 232 (AUG/JAN) 3:0
Wave Propagation in Structures

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

S Gopalakrishnan

Doyle, J.F., Wave propagation in Structures, Springer Verlag, New York, 1989.
Grof, K.F., Wave motion in Elastic Solids, Dover, New York, 1975.
Current literature.

AE 234 (JAN) 3:0
Engineering Optimization

Constrained and unconstrained minimization of linear and nonlinear functions of one or more variables, necessary and sufficient conditions in optimization, KKT conditions, numerical methods in unconstrained optimization, one dimensional search, steepest descent and conjugate gradient methods, Newton and quasi-Newton methods. Finite difference, analytical and automatic differentiation, linear programming,

numerical methods for constrained optimization, response surface methods in optimization, orthogonal arrays, stochastic optimization methods.

Ranjan Ganguli

Ranjan Ganguli, Engineering Optimization: A Modern Approach, Universities Press, 2010.

AE 235 (JAN) 3:0
Non-Destructive Testing and Evaluation

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

M R Bhat
Pre-requisite: AE 221 or equivalent.

Sharpe, R.A., Research Techniques in NDT, Metals Handbook -Vol.17.
Current Literature.

AE 238 (AUG/JAN) 3:0
Rotary Wing Aeroelasticity

Review of structural dynamics. Dynamics of rotating beams: hinged rigid blades, elastic blades, rotor speed characteristics and fan plots, blades in flap, lag and torsion. Aerodynamic loads, forced response and vibration, harmonic balance method, finite element in time. Vehicle trim. Stability analysis methods: constant coefficients, Floquet theory. Blade aeroelastic instabilities. Ground resonance and air resonance.

Ranjan Ganguli

Bielawa, R.L., Rotary Wing Structural Dynamics and Aeroelasticity, AIAA Education Series, 1992.
Johnson, W., Helicopter Theory, Dover, 1994.
Bramwell, Done, Balmford, Bramwell's Helicopter Dynamics, Butterworth-Heineman, 2001.
Current Literature.

AE 240 (JAN) 3:0
Modal analysis: Theory and Applications

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

S B Kandagal

Ewins, D.J., Modal analysis: Theory and Practice, Research Studies Press Ltd., England, 2000.
Clarence W. de Silva, Vibration: Fundamentals and Practice, CRC press New York, 1999.
Kenneth G. McConnel, Vibration testing: Theory and Practice, John Wiley & Sons, Inc., New York, 1995.

AE 241 (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.

S B Kandagal

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 245 (AUG) 3:0
Mechanics and Thermodynamics of Propulsion

Introduction to propulsive devices, air-breathing and non-air-breathing systems. Performance parameters, cycle analysis of ramjet, turbo-jet, turbo-fan and turbo-prop engines, afterburners. Rotating components: centrifugal and axial compressors, axial turbines. Non-rotating components: combustion chambers, intakes and nozzles.

D Sivakumar and Santosh Hemchandra

Hill, P.G., and Peterson, C., Mechanics and Thermodynamics of Propulsion, Addison-Weseley, 1992.
Mattingly, J.D., Elements of Gas Turbine Propulsion, Tata McGraw-Hill, 2005.
Saravanamuttoo, H.I.H., Rogers, C.F.C., and Cohen, H., Gas Turbine Theory, Pearson Education, 2001.
Kerrebrock, J.L., Aircraft Engines and Gas Turbines, MIT Press, 1977.

AE 246 (JAN) 3:0
Combustion

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

K N Lakshmisha

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

AE 247 (JAN) 3:0
Aircraft Engines

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

T S Sheshadri and D Sivakumar

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

AE 248 (JAN) 3:0
Rocket Propulsion

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

K N Lakshmisha and Charlie Oommen

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

AE 249 (AUG) 3:0
Introduction to Acoustics - I

Conservation equations, wave equation, acoustic energy, intensity and source power, spherical waves, frequency content of rounds, levels and the decibel Fourier series and long duration rounds. Reflection, transmission and excitation of plane waves, specific acoustic impedance, multi-layer transmission and reflection, radiation from vibrating bodies. Monopoles and Green's functions. Reciprocity in acoustics.

T S Sheshadri

Allan d'Pierce, Acoustics McGraw Hill Book Company, 1981.

AE 250 (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: Thermodynamical 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.

S. Chaudhuri and S. Hemchandra

Pre-requisites: AE 246 or equivalent, AE 203 or equivalent. These can however be waived after discussion with the course instructors.

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 review literature

AE 258 (JAN) 3:0
Robust Control System Synthesis for Aerospace Vehicles

Control system specifications for aerospace vehicles, robustness issues: robust stability and robust performance, PID controller, dead beat control, eigen structure assignment techniques, LQR, Kalman filter and implementation, LQG/LTR, H2 and H control optimization, LMI methods, LFT & µ- synthesis.

Introduction to neuro-fuzzy control, examples of state, output feedback and tracking control systems for aerospace vehicles: MATLAB/simulink implementation

M Seetharama Bhat

Pre-requisite: AE 259 or equivalent.

Zhou, K., Doyle, J.C., and Glover, K., Robust and Optimal Control, Prentice-Hall, 1996.
Green, M., and Limebeer, D.J.N., Linear Robust Control, Prentice Hall, NJ, 1995.
Lin, C-F, Advanced Control System Design, Prentice Hall, 1994.
Leondes, C.T.(ed), Control and Dynamic Systems, Series Publications, Academic Press, NY.
Recent journal publications.

AE 259 (AUG) 3:0
Navigation, Guidance and Control

Navigation and guidance: continuous waves and frequency modulated radars, MTI and Doppler radars; types of navigation; LORAN, Decca, Omega, VOR, INS GPS; guided missiles, guidance laws: pursuit, LOS and PN laws.
Control: Control systems – classical linear time invariant control systems, transfer function representations, stability, time domain characteristics, frequency domain characteristics, root locus, Nyquist and Bode plots, Exposure to state space analysis.

D Ghose and V Mani

Skolnik, M.I., Introduction to Radar Systems, McGraw-Hill, 1982.
Zarchan, P., Tactical and Strategic Missile Guidance, AIAA, 2004.
Nise, N., Control Systems Engineering, Wiley, 4th Ed., 2004.
Kayton, M., and Fried, W.R., Avionics Navigation Systems, John Wiley.
Bryson, A.E., and Ho, Y-C, Applied Optimal Control, Taylor and Francis, 1975.
Lin, C-F, Advanced Control Systems Design, Prentice Hall, 1994.
Lecture notes

AE 260 (AUG) 3:0
Linear Control Systems Design

Review of classical control systems, motivation for modern control design, state space representation of dynamical systems, review of linear algebra and matrix theory, linearization, time response of linear systems in state space form, stability, controllability and observability of linear systems, numerical methods in systems engineering, pole placement control design. pole placement observer design. Lyapunov stability theory for autonomous systems, static optimization, optimal control design. Linear Quadratic Regulator (LQR) theory and its extensions. An overview of LQ observer and Kalman Filter theory for state estimation. Overview

of flight dynamics. Application of linear system theory for flight control design.

Radhakant Padhi

Pre-Requisite: AE 259/260 or equivalent, Familiarity with MATLAB

Nise, N., Control Systems Engineering, Wiley, 4th Ed., 2004.
Ogata K., Modern Control Engineering, Third Ed., Prentice Hall, 1999.
Gopal, M., Modern Control System Theory, Second Ed., Wiley Eastern Ltd., 1993.
Kreyszig, E., Advanced Engineering Mathematics, 8th Ed., Wiley, 2004.
Bryson, A.E., and Ho, Y-C, Applied Optimal Control, Taylor and Francis, 1975.
Nelson, R.C., Flight Stability and Automatic Control, McGraw Hill, 1989.
Current Literature
Lecture Notes

AE 261 (AUG) 3:0
Space Dynamics and Control

Elements of orbital mechanics, orbit determination, orbital transfer and rendezvous, orbital perturbations, station keeping/orbit control. Spacecraft attitude dynamics, spin stabilization, gravity gradient, dual spin stabilization, three-axis stabilization and control. Altitude estimation, G P S Systems and case studies.

M Seetharama Bhat

Chobotov, V.A., Orbital Mechanics, 3rd Edition, AIAA, 2002.
Kaplan, M.H., Modern Spacecraft Dynamics and Control, Wiley, 1976.
Brown, C.D., Spacecrafts Mission Design, AIAA, 2002.
Sidi, M.J., Spacecrafts Dynamics and Controls, Cambridge University Press, 1997.
Bong Wie, Space Vehicle Dynamics and Control, AIAA 1998.

AE 262 (JAN) 3:0
Guidance Theory and Applications

Fundamentals of guidance; interception and avoidance; taxonomy of guidance laws, classical and empirical guidance laws; applied optimal control and optimal guidance laws; differential games and pursuit evasion problems. Recent advances in guidance theory. Collision detection and avoidance strategies. Applications to guided missiles. Unmanned aerial vehicles and mobile robots.

Debasish Ghose and A Ratnoo

Zarchan, P., Tactical and Strategic Missile Guidance, AIAA Publications, 4th Edition, 2002.
G.M. Siouris, Missile Guidance and Control Systems, Springer Verlag, 2004.
N.A.Sneyhdor, Missile Guidance and Pursuit, Ellis Horwood Publishers, 1998.
Current Literature

AE 264 (JAN) 3:0
Principles of Aerospace Navigation

Aerospace missions, geometric concepts of navigation, elements of geodesy, coordinate systems and their interrelationship, fundamentals of quarternion algebra. Inertial navigation principles, inertial sensors and operating principles, gyroscopes and accelerometers, ring laser gyroscopes, fibre optic gyroscopes, MEMS gyroscopes and accelerometers, satellite navigation systems, GPS and GNSS, augmented satellite navigation, hybrid navigation concepts.

P R Mahapatra

Kayton, M., and Fried, W.R. Eds., Avionics Navigation Systems, 2nd Edition, John Wiley, 1996.
Siouris, G.M., Aerospace Avionics systems – A Modern Synthesis, Academic Press 1993.

AE 265 (AUG/JAN) 3:0
Biologically Inspired Computing and its Applications

Introduction, neural networks – different learning techniques, McCulloch-Pitts neuron, perceptrons, delta rule, multilayer perceptron networks, radial basis function network, self-organizing networks. Introduction to evolutionary computing and GA, GA terminology and operators (mutation, crossover, inversion). Selection, replacement and reproduction strategies. Fitness, proportional, random, and tournament and rank based selection. Swarm intelligence – basic ideas, swarm behavior, flocking, self-organization, adaptation, multi-agent systems, trail laying, self-assembling, task handling, combinatorial optimization. Applications of biologically inspired algorithms in engineering.

S N Omkar

Prerequisite: Working knowledge in MATLAB or any other programming language

Bonabeau, E., Dorigo, M., and Theraulaz, G., Swarm Intelligence: From Natural to Artificial Systems, Oxford University Press, 1999.
Simon Haykin, Neural Networks – A Comprehensive Foundation, 2nd Edition, Prentice-Hall, Inc., 1999.

Michalewicz, Z., Genetic Algorithms+Data Structures=Evolution Programs, 3rd Edn, Springer-Verlag, Berlin, 1996.
Current literature

AE 266 (AUG) 3:0
Introduction to Neural Network and Engineering Applications

Introduction, network topology, learning–supervised, unsupervised and reinforced; perception and adaline, back-propagation and multi-layer feed-forward network, radial basis function network, recurrent networks, nonlinear airfoil characterization, online monitoring of manufacturing process, medical diagnosis, data screening.

S N Omkar

Haykin, S., Neural Networks: A Comprehensive Foundation, New Jersey, Prentice-Hall, Inc., 1999.
Current literature.

AE 268 (AUG) 2:1
Numerical Programming

Floating point arithmetic, linear systems, nonlinear equations, Eigen value and eigen vector problems, interpolation and polynomial approximation, basics of iterative methods, numerical methods for ordinary differential equations, numerical optimization, numerical methods for partial differential equations, numerical integration, engineering applications.

S N Omkar

Erwin Kreyszig, Advanced Engineering Mathematics, 8th Edition, Wiley.
Phillips, G.M.M., and Peter J. Taylor, Theory and Applications of Numerical Analysis, 2nd Edition, Elsevier Science & Technology Books.
John J Mathews and Kurtis D Fink, Numerical Methods using Matlab, 4th Edition, Pearson Prentice Hall.
William H Press, Saul A Teukolsky, William T Vetterling and Brain P Flannery, Numerical Recipes in C, 2nd Edition, Cambridge University Press.

AE 271 (AUG) 2:1
Flight Vehicle Design

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

S N Omkar

Daniel P Raymer, Aircraft Design: A Conceptual Approach, AIAA Education series.
Jan Roskam, Airplane Design" Part É– VIII, Roskam Aviation and Engineering Corporation.
Thomas C Corke, Design of Aircraft, University of Notre Dame, Prentice Hall.

AE 276 (JAN) 1:2
Experimental Techniques

Basic concepts of measurement, standards, error analysis, modern instrumentation systems. Dimensional analysis, experiments design, advanced techniques of measurements in fluid mechanics, solid mechanics, combustion and controls. Experiments in aerodynamics, structural mechanics, combustion and control.

Faculty

Experimental methods for Engineers
Holman Doeblin E.O., Measurement System.
Hand outs on the experiments.

AE 281 (JAN) 3:0
Introduction to Helicopters

Hover, axial flight and autorotation, rigid blade flapping in forward flight, multi-blade coordinates, different reference planes. Helicopter quasi-steady and unsteady aerodynamics, rotor wake modeling and dynamic stall. Floquet theory, introduction to rotor control performance and vibration. Helicopter design process.

Ranjan Ganguli and S N Omkar

Gessow, A., and Myers, G.C. Jr., Aerodynamics of the Helicopter. Frederick, Unger Publishing Co., New York, Re-published, 1967.
Leishman, G.J., Principles of Helicopter Aerodynamics, Cambridge University Press, 2000.

AE 282 (JAN) 3:0
Unmanned Aerial Vehicles

History of Unmanned Air Vehicle (UAV) development. Unmanned aircraft systems: coordinate frames, kinematics and dynamics, forces and moments, lateral and longitudinal autopilots. UAV navigation: accelerometers, gyros, GPS. Path planning algorithms: Dubin's curves, way-points, Voronoi partitions. Path following and guidance: Straight line and curve following, vision based guidance; Future directions and the road ahead.

Ashwini Ratnoo

Pre-requisites: AE 220, AE 259

Randal W.Beard and Timothy W.McLain: Small Unmanned Aircraft: Theory and Practice, Princeton University Press, 2012
Kimon P.Valavanis: Advances in Unmanned Aerial Vehicles: State of the Art and the Road to Autonomy, Springer, 2007

Current Literature

AE 299 (0:19)
Dissertation Project

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

Faculty

AE 315 (JAN) 3:0
Unsteady Flow

Examples of unsteady flows, impulsively started flows. Theory of linear and weakly nonlinear oscillations and waves, stability. DNS and LES for transitional and turbulent flows.

Joseph Mathew

Pre-requisite: AE 203 or equivalent; Consent of Instructor

Lighthill, J., Waves in Fluids, Cambridge University Press, 1978.
Drazin, P.G., and Reid, W.H., Hydrodynamic Stability, Cambridge University Press, 1991.
Current literature.

AE 316 (JAN) 3:0
Hydrodynamic Stability

Hydrodynamic stability theory for laminar-turbulent transition. Linearized flow equations, normal-mode analysis, the Eigen-Value Problem (EVP) and instability criteria: Rayleigh equation, discussion of Kelvin-Helmholtz, Rayleigh-Taylor, Richtmyer-Meshkov, Rayleigh-Benard and other instabilities.
Boundary layer stability: Orr-Sommerfeld equations, Tollmien-Schlichting waves, dual role of viscosity. Introduction to absolute instability, secondary instability theories.
Weakly non-parallel shear flow instability: Parabolized Stability Equation (PSE) methods, extensions to include nonlinearity.
Global stability theory, non-parallel two and three—dimensional flow with multiple inhomogeneous directions: BiGlobal, TriGlobal methods. Non-modal treatment of hydrodynamic stability as an Initial Value Problem (IVP).

Arnab Samanta

Pre-requisite: AE 203 or equivalent; consent of Instructor.

Schmid, P. & Henningson, D., Stability and transition in shear flows, Springer, 2001
Drazin, P.G. & Reid, W.H., Hydrodynamic stability, Cambridge University Press, 2004
Current literature

AE 328 (AUG/JAN) 3:0
Research Techniques in Non Destructive Evaluation

Quantitative non destructive evaluation involved probabilistic methods of quality control and life assessment. Signal analysis and image processing in NDE, ultrasonic, thermographic and tomographic methods for evaluation of composites.

M R Bhat

(ASM) American Society of Metal Hand Book, Volume 17.
Thompson, D.O., and Chimenti, D.E. Eds, Review of progress in quantitative Non Destructive Evaluation. Annual Conference proceedings.

AE 330 (AUG) 3:0
Dynamics of flow past on oscillating wing

Small disturbance flow past a wing and a wing section, unsteady incompressible potential flow past an oscillating airfoil and wing, unsteady compressible subsonic potential flow past an oscillating airfoil and wing, unsteady compressible supersonic potential flow past an oscillating airfoil and wing.

Kartik Venkatraman

Pre-requisite: An understanding of mechanics.

Josep Katz and Allen Plotkin, Low-speed aerodynamics, Cambridge University Press, 2001.
Tuncer Cebeci, Max Platzer, Hsun Chen, Kuo-cheng Chang, Jian P Shao, Analysis of low speed unsteady airfoil flows, Springer, 2005.

AE 355 (JAN) 3:0
Advanced Topics in Electromagnetic Scattering

Oscillations of a sphere, Rayleigh scattering and Mie scattering from ablate spheroids, effect of dielectric constant on scattering cross sections, numerical examples of Mie resonances in scattering; solutions of Maxwell's equations for scattering from arbitrary cross sections, applications of perturbation techniques, extended T-matrix approach to RCS computations for spacecraft structures, comparisons with method of moment solutions and asymptotic techniques; Fundamentals of propagation through and scattering from chiral media, RCS modification using chirality, design to geometric fixed structures for EM scattering.

N Balakrishnan

Stratton, J.A., Electromagnetic Theory, McGraw-Hill Company, New York & London 1941.
Waterman, P.C., Numerical Solutions of Electromagnetic problems, Chapter 3 Volume 7 Mitra, R. Ed., Computer Techniques in Electromagnetics, Pergamon Press 1973.
Special issue on Chiral media, Electromagnetics, 1990.

AE 357 (AUG/JAN) 3:0
Applied Nonlinear Control

Introduction and motivation, phase plane analysis, mathematical preliminaries. Review of functional analysis, topology and matrix theory; Lyapunov stability theory: autonomous systems; back-stepping design; dynamic inversion (feedback linearization). Applications of neural networks in control system design, neuro-adaptive control, nonlinear observers, Lyapunov stability theory: non-autonomous systems, adaptive control, advanced nonlinear flight control.

Radhakant Padhi

Pre-Requisite: AE 259/260 or equivalent, familiarity with MATLAB

Marquez, H.J., Nonlinear Control Systems Analysis and Design, Wiley, 2003.
Slotine, J.J.E., and Li, W., Applied Nonlinear Control, Prentice Hall, 1991.
Khalil, H. K., Nonlinear Systems, Prentice Hall, 1996.
Behera, L., and Kar, I., Intelligent Systems and Control, Oxford Univ. Press, 2009.
Current Literature.
Lecture Notes.

AE 360 (JAN) 3:0
Nonlinear Mechanics of Composite Structures

Introduction to classical geometrical and physical non-linearities and non-classical geometro-physical non-linearities in structural mechanics. Mechanics of composite lamina and laminates including response and failure as affected by nonlinearities. Variational asymptotic methods of constructing nonlinear composite beam, plate and shell theories. Non-classical effects resulting from non-linearities. Effects of nonlinearities on stability of thin-walled structures. Introduction to nonlinear finite element analysis including mixed formulations. Applications to engineering structures like pipes, springs and rotor blades.

Dineshkumar Harursampath

Pre-requiste: AE224 or equivalent

Hodges, D.H., Nonlinear Composites Beam Theory, Progress in Astronautics & Aeronautics Series, 213, AIAA, 2006
Berdichevsky, V.L., Variational Principles of Continuum Mechanics, I. Fundamentals & II. Applications, Interaction of Mechanics & Mathematics Series, Springer, 2009
Current literature (International Journal of Nonlinear Mechanics, International Journal of Solids and Structures etc.).

AE 361 (JAN) 3:0
Applied Optimal Control and State Estimation

Introduction and motivation review of static optimization, calculus of variations and optimal control formulation; numerical solution of two-point boundary value problems: shooting method, gradient method and quasi-linearization; Linear Quadratic Regulator (LQR) design: Riccati solution, stability proof, extensions of LQR, State Transition Matrix (STM) solution; State Dependent Riccati Equation (SDRE) design; dynamic programming: HJB theory; approximate dynamic programming and adaptive critic design; MPSP Design; optimal state estimation: Kalman filter, extended Kalman filter; robust control design through optimal control and state estimation; constrained optimal control systems: Pontryagin minimum principle, control constrained problems, state constrained problems; neighbouring extremals and sufficiency conditions. Discrete time optimal control: Generic formulation, discrete LQR.

Radhakant Padhi

Naidu, D.S., Optimal Control Systems, CRC Press, 2002.
Sinha, A., Linear Systems: Optimal and Robust Control, CRC Press, 2007.
Bryson, A.E., and Ho, Y-C, Applied Optimal Control, Taylor and Francis, 1975.
Stengel, R.F., Optimal Control and Estimation, Dover Publications, 1994.
Sage, A.P., and White, C.C. III, Optimum Systems Control, 2nd Ed., Prentice Hall, 1977.
Kirk, D.E., Optimal Control Theory: An Introduction, Prentice Hall, 1970.
Lewis, F.L., Optimal Control, Wiley, 1986.
Current Literature
Lecture Notes

AE 362 (AUG) 3:0
Cooperative Control with Aerospace Applications

Introduction to cooperative control, mathematical preliminaries: algebraic graph theory, matrices for cooperative control, stability of formations. Consensus algorithms, consensus for single and double integrator dynamics, consensus in position, direction, and attitude dynamics. Distributed multi-vehicular cooperative control. Generalized cyclic pursuit; spacecraft formation flying. UAV applications in search, coverage, and surveillance of large areas, and in monitoring and controlling of hazards. Routing and path planning of UAVs. Role of communication. Operation in uncertain environments and uncertainty.

D Ghose

Shamma, J. (ed), Cooperative Control of Distributed Multi-Agent Systems, John Wiley, 2008.
Qu, Z., Cooperative Control of Dynamical Systems, Springer Verlag, 2009.
Ren, W., and Beard, R., Distributed Consensus in Multi-vehicle Cooperative Control: Theory and Applications, Springer, 2007.
Rasmussen, S., and Shima, T. (Eds.), UAV Cooperative Decision and Control: Challenges and Practical Approaches, SIAM Publications, 2008.
Current Literature.

AE 363 (JAN) 3:0
Kalman Filter And Applications

Brief introduction to randomness, probability, statistics, random processes, optimization, linear systems, and matrix theory. and Kalman filter formulations. Estimation with measurement noise alone and together with process noise. Linear, linearised, extended, particle and ensemble Kalman filters. Spring-mass-, damper system. State and parameter estimation, tracking, space debris, data fusion, GPS/INS integration, allied topics with measurement and process noise. Filter tuning to obtain the best possible optimum solutions.

Radhakant Padhi

Pre-Requisite: AE 259 or equivalent, Interest to learn the subject and use MATLAB to carry out the exercises, assignments, and term papers.

Gelb (Ed.): Applied Optimal Estimation, The MIT Press, 1974.
J. L. Crassidis and J. L. Junkins, Optimal Estimation of Dynamic Systems, CRC Press, 2004.
D. Simon, Optimal State Estimation, Wiley, 2006.
P. Zarchan and H. Musoff, Fundamentals of Kalman Filtering: A Practical Approach, AIAA, 2005.
M. S. Grewal and A. P. Andrews, Kalman Filtering Theory and Practice using Matlab, Wiley, 2001.
R. F. Stengel: Optimal Control and Estimation, Dover Publications, 1994.
Current literature

Atmospheric and Oceanic Sciences

M Tech Programme in Climate Science

Duration: 2 years
Total Credits: 64

Core Courses: 21 Credits

AS 203 3:0 Atmospheric Thermodynamics
AS 204 3:0 Atmospheric Radiation and Climate
AS 205 3:0 **Atmosphere and Ocean Dynamics**
AS 207 3:0 Introduction to Atmospheric Dynamics
AS 211 3:0 Observational Techniques
AS 216 3:0 Introduction to Climate System

One 3:0 Mathematics Course offered at (SERC/ Maths/CHE/CAOS/CEas)

Project: 28 Credits

Elective: A balance of 15 credits required to make up a minimum of 64 credits for completing the M Tech Programme.

AS 202 (JAN) 3:0
Geophysical Fluid Dynamics

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

Jai Sukhatme and D Sengupta

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

AS 203 (AUG) 3:0
Atmospheric Thermodynamics

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

A Chakraborty

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, J.M., and Hobbs, P.V., Atmospheric Science – An Introductory Survey, 2nd Edn, Academic Press, 2006.

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.

J Srinivasan and S K Satheesh

Petty, G.W., A first course in Atmospheric Radiation, Sundog Publishing, Madison, Wisconsin, 2nd edition, 2006.
Liou, K.N., Introduction to Atmospheric Radiation, Academic Press, San Diego, 2nd edition, 2002.

AS 205 (AUG) 3:0
Atmosphere and Ocean Dynamics

Introduction to weather and climate. Momentum, continuity and thermodynamic energy equations. Basic equations in isobaric coordinates. Balanced flow: inertial flow, cyclostrophic flow. Thermal wind, calculation of vertical velocities, circulation and vorticity. Planetary boundary layer, Boussinesq approximation. Atmospheric general circulation.
Introduction to physical oceanography, properties of sea water and their distribution, mixed layer, stratification and stability, ocean general circulation, thermohaline circulation, scale analysis, geostrophic currents, wind-driven ocean circulation, Ekman layer in the ocean, Sverdrup flow.

Ravi S Nanjundaiah and P. N. Vinayachandran

Holton, J.R., An Introduction to Dynamic Meteorology, 4th Edn , Elsevier, 2004.
Marshall, J. and R. A. Plumb, Atmosphere, Ocean and Climate Dynamics, Academic Press, 2008
Cushman-Roisin, B. and J-M Beckers, Introduction to Geophysical Fluid Dynamics, Academic Press, 2011.
Talley L. D., G. L. Pickard, W. J. Emery and J. H. Swift, Descriptive Physical Oceanography, 6th Edn, Elsevier, 2011.

AS 207 (AUG) 3:0
Introduction to Atmospheric Dynamics

Introduction to weather and climate. Momentum, continuity and thermodynamic energy equations. Basic equations in isobaric coordinates. Balanced flow: inertial flow, cyclostrophic flow. Thermal wind, calculation of vertical velocities, circulation and vorticity. Planetary boundary layer: atmospheric turbulence, Boussinesq approximation. Introduction to quasi-geostrophic systems. Atmospheric waves.

Ravi S Nanjundaiah

Holton, J.R., An Introduction to Dynamic Meteorology, 4th Edn , Elsevier, 2004.

AS 208 (JAN) 3:0
Satellite Meteorology

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

J Srinivasan and S K Satheesh

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

AS 209 (JAN) 3:0
Mathematical Methods in Climate Science

Review of probability and statistics: probability distributions, sample statistics. Confidence intervals. Hypothesis testing; goodness of fit tests, time-series analysis: Fourier transforms, principal component analysis (PCA).

V Venugopal

Papoulis, A., & U. Pillai, Probability, Random Variables and Stochastic Processes, 4th edition, McGraw Hill, 2002.
Wilks, D., Statistical Methods in the Atmospheric Sciences, 2nd edition, Academic Press, 2006.
O. Brigham, Fast Fourier Transforms, Prentice Hall, First Edition, 1974.
Press, W. H., S. A. Teukolsky, W. T. Vetterling, and B. P. Flannery, Numerical Recipes in C/Fortran: The Art of Scientific Computing, 3rd Ed., Cambridge Univ. Press, 2007.

AS 211 (JAN) 2:1
Observational Techniques

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

G S Bhat and S.K. Satheesh

Guide to Meteorological Measurements and Methods of Observation, World Meteorological Organization Publication No. 8, 7th Edition, WMO, Geneva. available on line at www.wmo.int
DeFelice, T.P., An Introduction to Meteorological Instrumentation and Measurement, Prentice Hall, 1998.

AS 216 (AUG) 3:0
Introduction to Climate System

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

Govindasamy Bala

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

AS 301 (JAN) 3:0
Tropical Climate

Annual and seasonal mean energy budget, dominant modes of variability, El-Nino and Southern oscillation, Pacific Decadal oscillation, tropical biennial oscillation, quasi-biennial oscillation, Madden Julian oscillation, North Atlantic oscillation, Indian Ocean Dipole, monsoon, tropical cyclones, interactions and energy exchange between different scales.

Arindam Chakraborty

Hastenrath, S., Climate Dynamics of the Tropics, Kluwer Academic Publishers, 1996.
Diaz, H.F., and Markgraf, V.(Eds), El-Nino and the Southern Oscillation, Cambridge University Press, 2000.
Philander, G., El-Nino and Southern Oscillation, Academic Press, 1990.

AS 306 (AUG) 3:0
Radiative Transfer in the Atmosphere

Electromagnetic spectrum, fundamentals of atmosphere and radiation, laws of thermal radiation, emissivity, absorptivity and albedo of surfaces, Beer's law, theory of scattering, principles of radiative transfer, radiative transfer in a plane parallel atmosphere, approximation of radiative transfer, the role of radiation in climate.

J Srinivasan and S K Sateesh
Pre-requisite: AS 202, AS 203, AS 207 or an equivalent background in the dynamics and thermodynamics of the atmosphere

Liou, K.N., An Introduction to Atmospheric Radiation, Academic Press, 1980.
Thomas, G.E., and Stammes, K., Radiative transfer in the atmosphere and oceans, Cambridge University Press, 1999.
Relevant journal articles. Online materials.

AS 311 (AUG) 3:0
Topics in Tropical Convection

Meso-scale organization of deep convection, parameterization of moist convection, momentum transport by organized convection, implications of convection for large scale flows, implication of convective quasi-equilibrium for large scale flow, super parameterization, aerosols and clouds; clouds and climate change

J Srinivasa, G S Bhat, Arindam Chakraborty and Ravi S Nanjundiah

Pre-requisites: AS 207 and AS 203.

Emanuel, KA : Atmospheric Convection. Oxford University Press, 1994
Heintzenberg, J and R J Charlson: Clouds in the Perturbed Climate System. The MIT Press, Cambridge, Mass. USA

CIVIL ENGINEERING

M.E. Programmes
Geotechnical Engineering

Hard Core: 24 Credits (All courses are mandatory)

CE 201 3:0 Basic Geomechanics
CE 202 3:0 Earthquake Geotechnical Engineering
CE 203 3:0 Earth and Earth Retaining Structures
CE 204 3:0 Foundation Engineering
CE 205 3:0 Geoenvironmental Engineering
CE 206 3:0 Ground Improvement and Geosynthetics

One 3:0 core course from either the Structural Engineering or the Water Resources and Environmental Engineering streams
A suitable 3:0 mathematics course will be identified by the department at the beginning of the term.

Project: 22 Credits
CE299 0:22 Dissertation Project
Electives: 18 Credits, of which at least 9 credits must be from among the group electives listed below.

CE 231 2:0 Soil Stabilization by Admixtures
CE 232 2:0 Fundamentals of Soil Behaviour
CE 234 2:0 Soil Dynamics
CE 236 2:1 Behaviour and Testing of Unsaturated Soils
CE 237 2:0 Rock Mechanics
CE 239 3:0 Computational Geotechnics
CE 240 3:0 Engineering Seismology
CE 241 3:0 Introduction to the theory of Plasticity
CE 242 3:0 Probabilistic Methods in Civil Engineering
CE 266 3:0 Pavement Engineering

Water Resources and Environmental Engineering
Hard Core: 24 Credits (All courses are mandatory)

CE 207 3:0 Computational Fluid Dynamics in Water Resources Engineering
CE 208 3:0 Surface Water Hydrology
CE 209 3:0 Ground Water and Contaminant Hydrology
CE 210 3:0 Systems Techniques in Water Resources & Environmental Engineering.
CE 211 3:0 Water Quality Modeling
CE 212 3:0 Design of Water Supply and Sewerage Systems

One 3:0 core course from either the Geotechnical Engineering or the Structural Engineering streams
A suitable 3:0 mathematics course will be identified by the department at the beginning of the term.

Project: 22 Credits
CE299 0:22 Dissertation Project

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

CE 255 3:0 Urban Hydrology
CE 256 3:0 Stochastic Hydrology
CE 258 3:0 Remote Sensing and GIS for Water Resources and Environmental Engineering
CE 259 3:0 Regionalization in Hydrology and Water Resources Engineering.

ME 201 3:0 Fluid Mechanics
AS216 3:0 Introduction to Climate Systems

Structural Engineering
Hard Core: 24 Credits (All courses are mandatory)

CE 214 3:0 Solid Mechanics
CE 215 3:0 Mechanics of Structural Concrete
CE 216 3:0 An Introduction to Finite Elements in Solid Mechanics
CE 217 3:0 Linear Structural Dynamics
CE 218 3:0 Optimization Methods
CE 219 3:0 Stability of Structures

One 3:0 core course from either the Geotechnical Engineering or the Water Resources and Environmental Engineering streams
A suitable 3:0 mathematics course will be identified by the department at the beginning of the term.

Project: 22 Credits
CE 299 0:22 Dissertation Project

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

CE 273 3:0 Fracture Mechanics
CE 275 3:0 Nonlinear FEM in Structural Engineering
CE 276 3:0 Structural Masonry
CE 287 3:0 Stochastic Structural Dynamics
CE 291 3.0 Uncertainty Modelling and Analysis
CE 294 3:0 Monte Carlo Simulations in Structural Mechanics

M Tech Programme in Transportation and Infrastructure Engineering

Hard Core: 25 Credits (All courses are mandatory)

CE 266 3:0 Pavement Engineering
CE 212 3:0 Design of Water Supply and Sewerage Systems
CE 263 3:0 Modelling Transport and Traffic
CE 218 3:0 Optimization Methods
MG 223 3:0 Applied Operations Research
ST 210 3:1 Principles and Applications of GIS and Remote Sensing
MA 261 3:0 Probability Models
MG 221 2:1 Applied Statistics

Project: 22 credits

CE 299 0:22 Dissertation Project

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

CE 204 3:0 Foundation Engineering
CE 206 3:0 Ground Improvement and Geosynthetics
CE 267 3:0 Transportation Statistics and Micro-simulation
CE 215 3:0 Mechanics of Structural Concrete
CE 216 3:0 Introduction to Finite Elements in Solid Mechanics
ST 202 3:0 Renewable Energy – Technology, Economics and Environment
ST 203 3:0 Technology and Sustainable Development

CE 201 (AUG) 3:0
Basic Geo-mechanics

Introduction to genesis of soils, basic clay mineralogy; Principle of effective stress, permeability and flow; Stresses and Strains; Mohr circles, failure criteria, soil laboratory tests; Critical state and stress paths. Shear Strength and Stiffness of Sands; Consolidation, shear strength and stiffness of clays

Tejas. G Murthy

Wood, D.M., Soil Behaviour and Critical State Soil Mechanics, Cambridge University Press, 1991.
Bolton, M.D. A Guide to Soil Mechanics, Cambridge University Press, 1991.
Salgado, R., The Engineering of Foundations, McGraw Hill, 2008.

CE 202 (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

G Madhavi Latha

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

CE 203 (AUG) 3:0
Earth and Earth Retaining Structures

Lateral earth pressure coefficients, Rankine and Coulomb theories. Graphical constructions, passive earth pressure with curved rupture surfaces, arching, stability of retaining walls, stability of vertical cuts. Braced excavations, anchored sheet piles, stability of infinite slopes, stability of finite slopes. Methods of slices - Swedish, Morgenstern and Price methods. Stability analysis of earth and rock-fill dams.

Jyant Kumar

Terzaghi, K., Theoretical Soil Mechanics, John Wiley, 1965.
Taylor, D.W., Fundamentals of Soil Mechanics, John Wiley, 1948.
Bowles, J.W., Analysis and Design of Foundations, 4th and 5th Ed., McGraw-Hill, 1988 & 1996.
Lambe, T.W. and Whitman, R.V., Soil Mechanics, Wiley Eastern Limited, 1976.

CE 204 (AUG) 3:0
Foundation Engineering

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

T G Sitharam

Bowles, J.W., Foundation Analysis and Design, 5th Edn., McGraw-Hill, 1996.
Das, M. B., Principles of Foundation Engineering, Brooks/Cale Engineering Division, 1984.

CE 205 (JAN) 3:0
Geo-environmental Engineering

Source, production and classification of wastes. Soil pollution processes. Physical, chemical and biological interactions in soil. Effects on geotechnical properties and case studies. Waste disposal facilities such as landfills and impoundments, slurry walls, etc. Barrier systems- basic concepts, design and construction, stability, compatibility and performance. Transport in subsurface; reuse of waste materials. Contaminated site remediation.

P V Sivapullaiah

Daniel, D. E., Geotechnical Practice for Waste Disposal, Chapman and Hall, London, 1993.
Reddi, L. N., and Inyang, H. F. Geoenvironmental Engineering- Principles and Applications Marcel Dekker, Inc., 2000.
Sharma, H. D., and Lewis, S.P. Waste Containment Systems, Waste Stabilization and Landfills: Design and Evaluation, John Wiley & Sons, Inc. New York, 1994.

CE 206 (JAN) 3:0
Ground Improvement and Geosynthetics

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

G L Sivakumar Babu and G. Madhavi Latha

Manfred R. Hausmann, Engineering Principles of Ground Modification, McGraw-Hill Pub, Co., 1990.
Jones, C.J.E.P., Reinforcement and Soil Structures, Butterworth Publications, 1996.
Koerner, R. M., Designing with Geosynthetics, Prentice Hall Inc. 1998.

CE 207 (Aug) 3:0
Computational Fluid Dynamics in Water Resources Engineering

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

M. S. Mohan Kumar

Computational Fluid Dynamics: Applications in Environmental Hydraulics, edited by Paul D. Bates, Stuart N. Lane, Robert I. Ferguson, Wiley; 1st edition, 2007.
Computational Fluid Dynamics: A Practical Approach, by Jiyuan Tu, Guan Heng Yeoh, Chaoqun Liu, Elsevier, 2013.
Computational Fluid Dynamics in Drinking Water Treatment, by Bas Wols, IWA Publishing, 2011.
Computational Fluid Dynamics for Engineers, By Andersson et al, Cambridge University Press, New York, 2012.
Fundamentals of Computational Fluid Dynamics, by Tapan K Sinha, University Press, 2004.
Applied Numerical Analysis, by Curtis F. Gerald and Patrick O. Wheatley, Addison and Wesley, 1994

CE 208 (AUG) 3:0
Surface Water Hydrology

Review of basic hydrology, hydrometeorology, infiltration, evapotranspiration, run-off and hydrograph analysis. Flood routing - lumped, distributed and dynamic approaches, Hydrologic statistics. Frequency

analysis and probability. Introduction to environmental hydrology. Urban hydrology. Design issues in hydrology.

V V Srinivas

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

CE 209 (Aug) 3:0
Ground Water and Contaminant Hydrology

Groundwater movement and balance, equations of flow. Well hydraulics: Models and methods, pumping tests, slug tests, aquifer tests - porous and fractured media, regional groundwater resources evaluation, groundwater recharge, groundwater monitoring, groundwater quality, mass transport in groundwater. Tracer tests. Scale effects of dispersion. Solute transport modeling. Transport in fractured media.

M Sekhar

Freeze, A.R., and Cherry, J.A., Ground Water, Prentice Hall, 1979.
Domenico, P.A., and Schwartz, F.W., Physical and Chemical Hydrogeology, John Wiley, 1990.
Batu, V., Aquifer Hydraulics, John Wiley, 1998.
Lerner, D.N., Issar, A.S., and Simmers, I., Groundwater Recharge, International Contributions to Hydrogeology, Vol.8, Verlag Heinz Heise, 1990.
Nielsen, D.M., Practical Handbook of Groundwater Monitoring, Lewis Publishers, 1991.

CE 210 (AUG) 3:0
Systems Techniques in Water Resources and Environmental Engineering

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

D Nagesh Kumar

Loucks, D.P., Stedinger, J.R. and Haith, D.A., 'Water Resources Systems Planning and Analysis', Prentice Hall, Englewood Cliffs, N.J, 1981.
Vedula, S. and Mujumdar, P. P., 'Water Resources Systems: Modelling Techniques and Analysis', Tata-McGraw Hill, New Delhi, 2005.
Mays, L.W. and Tung, Y-K,'Hydrosystems Engineering and Management', McGraw Hill, 1992.

CE 211 (JAN) 3:0
Water Quality Modelling

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.

M Sekhar

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

CE 212 (JAN) 3:0
Design of Water Supply and Sewerage Systems

Basics of hydraulics and hydrology. Introductory chemistry and biology. Water distribution systems, water processing, operation of networks. Design of water supply units, wastewater flows and collection systems, wastewater processing. Advanced wastewater treatment and water reuse.

M S Mohan Kumar

Mark J Hammer & Mark J Hammer Jr., Water and Wastewater Technology, Fifth Edition, Pearson Prentice Hall, Columbus, USA, 2004.

CE 213 (JAN) 0:1j
Experimental Methods in Environmental Engineering

Water quality measurement – chemical and instrument methods, Contaminant transport through water and soil-water medium. Experiments on aeration. Experiments on water conveyance systems – pipes and open channels.

M Sekhar and M S Mohan Kumar

Current literature/ Laboratory manuals

CE 214 (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 theorem, Betti-Maxwell reciprocal theorem, Principle of stationary potential energy, Torsion in circular and non-circular shafts and thin-walled tubes, warping. Pure bending of thin rectangular and circular plates, small deflection problems in laterally loaded thin rectangular and circular plates. Outline of Mindlin plate theory. Introduction to yield and plasticity.

Narayan K. Sundaram

Fung, Y. C. and Pin Tong, Classical and Computational Solid Mechanics, World Scientific, 2001
Boresi, A.P., and Lynn P.P., Elasticity in Engineering Mechanics, Prentice Hall 1974.
Theoretical Elasticity, A.E. Green and W. Zerna, 1968, Dover Publications

CE 215 (AUG) 3:0
Mechanics of Structural Concrete

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

J.M. Chandra Kishen

Nilson, A. H., Darwin, D. and Dolan, C. W., Design of concrete structures, McGraw Hill, 2004
Lin and Burns, Design of Prestressed concrete structures, John Wiley and Sons, 2006

Agarwal and Shrikhande- Earthquake resistant design of structures, Prentice-Hall of India Pvt. Ltd. New Delhi, 2006.

CE 216 (AUG) 3:0
An Introduction to Finite Elements in Solid Mechanics

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

Debraj Ghosh

Zienkiewicz, O.C. and Taylor, R.L., The Finite Element Method: Vol. 1 (The Basis), Butterworth-Heinemann, 2000.
Cook R.D.. Malkus, D. S., Plesha and Witt, R.J., Concepts and Applications of Finite Element Analysis, Fourth edition, John Wiley and Sons.

CE 217 (AUG) 3:0
Linear Structural Dynamics

An overview of continuous dynamical systems; principle of virtual work; Hamilton's principle; Lagrangian equations of motion; equations of motion by Reynolds transport theorem; PDEs of motion for taut strings; Euler-Bernoulli beams and Kirchhoff plates; solutions of governing PDEs through separation of variables; orthonormal bases and eigenfunction expansions; Rayleigh-Ritz and weighted residual methods; finite element semi-discretizations of continuous dynamical systems; semi-discrete MDOF systems and eigenvalue problems; modal dynamics and the notion of an SDOF model; free and forced vibration responses; damped MDOF systems; structures under support excitations; a brief overview of eigensolution techniques; direct integration techniques including Euler and Newmark-beta methods.

D Roy

D Roy and G V Rao, 2012, Elements of Structural Dynamics: A New Perspective, John Wiley, New York.
L Meirovitch, 1984, Elements of Vibration Analysis, McGraw-Hill, New York.

CE 218 (JAN) 3:0
Optimization Methods

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

Ananth Ramaswamy

Arora, J.S. Introduction to Optimization, McGraw-Hill (Int.edition).1989.
Rao, S.S., Optimization: Theory and Applications. Wiley Eastern, 1992
Current Literature.
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CE 219 (JAN) 3:0
Stability of Structures

Analysis of beam columns. Stability functions. Behavior of ideal columns. Bifurcation buckling and limit point instability. Mechanical models of stability. Static and dynamic formulations. Energy methods. Finite element formulation. Lateral torsional buckling of beams. Buckling of frames. Imperfection sensitivity and post critical behavior. Buckling of beams on elastic foundations, arches and plates. Thermal buckling. Inelastic buckling. Dynamic analysis of stability. Parametric instabilities and stability under nonconservative forces. Divergence and flutter.

C S Manohar

S P Timoshenko and J M Gere, 1963, Theory of elastic stability, McGraw Hill, London.
G J Simtses and D H Hodges, 2005, Fundamentals of structural stability, Elsevier, Amsterdam.
J M T Thompson and G W Hunt, 1973, A general theory of elastic stability, John Wiley, London

CE 231 (AUG) 2:0
Soil Stabilization by Admixtures

Principles of soil stabilization. Role of admixtures. Purpose-based classification of soils. Methods of stabilization - lime, cement, bitumen and special chemicals; mechanisms, uses and limitations. Use of fly ash and other waste materials. Methods and applications of grouting; Application to embankments, excavations, foundations and sensitive soils.

P V Sivapullaiah

Ingles, O.G. and Metcalf, J.B., Soil Stabilization, Principles and Practice, Butterworths, 1972.
Bowen, R., Grouting in Engineering Practice, Allied Science Publishers Ltd., 1975.

CE 232 (AUG) 2:0
Fundamentals of Soil Behaviour

Origin of soils, identification of clay minerals, soil structure, soil classification, soil - water interactions in the environment. Effective stress concepts, role of mineralogy in hydraulic conductivity. Consolidation and shear strength of fine-grained soils. Problematic soils

M Sudhakar Rao & P Raghuveer Rao

J. K. Mitchell, Fundamentals of Soil Behaviour, John Wiley, 1993.
R. N. Yong & B. P. Warkentin, Soil Properties and Behaviour, Elsevier, 1975,
H. Y. Fang & J. L. Daniels, Introductory Geotechnical Engineering-An Environmental Perspective, Taylor and Francis, 2006

CE 234 (JAN) 2:0
Soil Dynamics

Fundamental of vibrations; analysis of free and forced vibrations using spring dashpot model; block vibration test for determining stiffness and damping coefficient of soil mass; formulation of the problem for the multi-degree freedom system; theories for foundations on elastic half space; effect of different pressure distribution; comparison with spring-dashpot model; wave propagation in bar and elastic media; different types of waves; resonant column test for determination of elastic and shear modulus; geophysical survey using reflection, refraction, steady state vibration and cross hole shear tests, liquefaction analysis; cyclic shear test; seismic bearing capacity of foundations and seismic earth pressures, vibration isolations.

Jyant Kumar

Richart, F.E., Woods, R.D. and Hall, J.R., Vibrations of soils and foundations. Prentice-Hall, 1970.
Major. A., Vibration Analysis and Design of Foundations for Machines and Turbines. Collets, 1962.
Robert W. Day., Geotechnical Earthquake Engineering Handbook, McGraw-Hill, 2002

CE 236 (JAN) 2:1
Behaviour and Testing of Unsaturated Soils

Identification and classification of expansive and collapsing soils, effective stress concepts, matric and osmotic suction, collapse, heave and strength characteristics of unsaturated soils, flow through unsaturated soils. Laboratory evaluation of swell pressure and swell potential, tests to evaluate collapse potential. Measurements of soil suction.

M Sudhakar Rao & P Raghuveer Rao

Blight, G.E. Mechanics of Residual Soils, Taylor & Francis Pub. 1997
Fredlund, D.G. and Rahardjo, H. Soil Mechanics for Unsaturated Soils, Wiley-Interscience Publications,1993

Nelson, J.D. and Miller, D.J. Expansive soils- Problems and Practice in Foundation and Pavement Engineering. Wiley-Interscience Pub. (1992)

CE 237 (JAN) 2:0
Rock Mechanics

Classification of inferential testing. Transitional materials engineering property evaluation. Laboratory methods and in-situ tests. Friction in rocks; elasticity and strength of rocks in situ stress determination. Application of rock mechanics in engineering, and underground opening. Slope stability and foundation problems.

T G Sitharam

Goodman, R.E., Rock Mechanics (2nd Edn.), John Wiley and Sons, 1982.
John. A. Franklin and Maurice B. Dusseault, Rock Engineering, McGraw-Hill Publishing Company, New York, 1989.

CE 239 (JAN) 3:0
Computational Geotechnics

Introduction to numerical modeling in geotechnical engineering. Review of basic concepts. Solution of nonlinear systems of equations. Finite difference method. Finite element method. Discrete element method. Measured soil response. Constitutive modeling of soil response. Artificial Neural Networks. Using finite difference, finite element and discrete element computer codes. Application for solving geotechnical engineering problems.

G Madhavi Latha

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

CE 240 (JAN) 3:0
Engineering Seismology

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

P. Anbazhagan

Earthquake Engineering – From Engineering Seismology to Performance-Based Engineering Edited by Bozorgnia, Y. and Bertero, V.V., CRC Press Washington 2004.
Leon Reiter, Earthquake hazard Analysis – Issues and Insights Columbia University Press New York 1990.
Steven L Kramer, Geotechnical Earthquake Engineering Pearson Education, 2003.

CE 241 (JAN) 3.0
Introduction to the Theory of Plasticity

1D plasticity and viscoplasticity; physical basis of plasticity; uniaxial tensile test & Bauschinger effect; phenomenological basis of assumptions in plasticity; Levy-Mises equations; yield criteria (Tresca, von Mises, Mohr-Coulomb, Drucker-Prager); geometry of yield surfaces; flow rules and hardening ; plastic / viscoplastic potentials; Drucker's postulate;convexity; normality; Illyushin's principle; shakedown; problems in rigid-perfectly plastic solids; slipline fields; introduction to upper and lower bounds; selected

rigid-perfectly plastic and elastic-plastic boundary value problems; advanced hardening models; introduction to computational plasticity; radial return and other integration algorithms

Tejas G Murthy & Narayan K Sundaram

Chakrabarty, J. Theory of Plasticity, Butterworth, 2006
Calladine, C.R., Plasticity for Engineers, Woodhead, 2000
Lubliner J., Plasticity Theory, Dover, 2008

CE 242 (Aug) 3:0
PROBABILISTIC METHODS IN CIVIL ENGINEERING (3:0)

Randomness, uncertainty, modeling uncertainty, engineering judgment, introduction to probability, measures of variability, probability theory, random variables, probability mass and density functions, moments of distribution, Bayes theorem, Stationary processes, autocovariance functions, functions of random fields, sampling techniques, concepts of sampling, sampling plans, decisions based on samplings. levels of reliability, loads and resistances, reliability methods, first order second moment, (FOSM) method, Hasofer-Lind approach, comparative discussion, simulation methods, random number generation, decision making, branching, use of fault tree and event tree analysis and examples in civil engineering.

G L Sivakumar Babu

Ang, A.H.-S. and Tang, W.H. (1975 and 1984). Probability Concepts in Engineering Planning and Design, Vol. 1 and Vol.2 , Basic Principles, John Wiley, New York.
Nathabandu T. Kottegoda and Renzo Rosso (1998) Statistics, Probability, and Reliability for Civil and Environmental Engineers, McGraw-Hill International edition.
Baecher, G.B. and Christian, J.T. (2003). Reliability and Statistics in Geotechnical Engineering, John Wiley and Sons, London and New York

CE 255 (AUG) 3:0
Urban Hydrology

Review of basic hydrology. Storm water runoff generation; return period; hydrologic risk; frequency analysis – IDF relationships; open channel flow in urban watersheds; interception storage, infiltration, depression storage; combined loss models; estimation of runoff rates from urban watersheds; flow routing; storm water drainage structures; storm water detention; structural and non-structural control measures; Source control techniques; urban storm water models. Introduction to urban ground water systems.

P P Mujumdar

Butler, D. & Davies, J.W., Urban Drainage, Spon Press, 2nd Edn., 2004.
Akan A.O and Hioughtalen R.J., Urban Hydrology, Hydraulics and Storm Water Quality – Engineering Applications and Computer Modeling, John Wiley & Sons 2003.
Hall, M.J., Urban Hydrology. Elsevier, 1984.
Shaw, E.M., Hydrology in Practice, 3rd Edn., Chapman & Hall, 1994.

CE 256 (JAN) 3:0
Stochastic Hydrology
Introduction to random variables, statistical properties of random variables. Commonly used probability distributions in hydrology. Fitting probability distributions to hydrologic data. Probability plotting and frequency analysis. Data generation. Modeling of hydrologic uncertainty - purely stochastic models, first order Markov processes. Analysis of hydrologic time series - auto correlation and spectral density functions. Applications to hydrologic forecasting.

P P Mujumdar

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

CE 258 (JAN) 3:0
Remote Sensing and GIS for Water Resources & Environmental Engg

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.

D Nagesh Kumar

Lillesand T.M. and Kiefer R.W. Remote Sensing and Image Interpretation, John Wiley & Sons, 2000.
Sabins, F.F. Remote Sensing - Principles and Interpretation, Freeman & Co., New York, 1986.
Heywood, I., Cornelius, S., and Carver, S. An Introduction to Geographical Information Systems, Pearson Education, 1998.

CE 259 (JAN) 3:0
Regionalization in Hydrology and Water Resources Engineering

Prediction in ungauged basins. Regional frequency analysis- probability weighted moments and its variations, stationary and non-stationary distributions, regional goodness-of-fit test. Approaches to regionalization of hydrometeorological variables and extreme events. Regional homogeneity tests. Prediction of hydrometeorological variables in gauged and ungauged basins, Estimation of probable maximum precipitation and probable maximum flood, and their use in hydrologic design.

V V Srinivas

Prerequisite: CE 208

Diekkrüger, B., Schröder, U., Kirkby, M. J., Regionalization in Hydrology, IAHS Publication no. 254, 1999.
Hosking, J. R. M., and Wallis, J. R., Regional Frequency Analysis: An Approach Based on L-Moments, Cambridge University Press, 1997.
Rao, A.R. and Srinivas, V.V., Regionalization of Watersheds - An Approach Based on Cluster Analysis, Series: Water Science and Technology Library, Vol. 58, Springer Publishers, 2008.

CE263 (AUG) 3:0
Modelling Transport and Traffic

Approaches to travel demand modelling; trip-based modelling approach, activity based travel demand modelling, land use-transport models; traffic flow theory; deterministic and stochastic models of traffic flows; delay and saturation flow models; pedestrian flow modeling; optimization of public transport system

Ashish verma

J. de D. Ortuzar and L.G. Willumsen, Modelling Transport, John Wiley and Sons, 2001.
A. D. May, *Traffic Flow Fundamentals*, Prentice–Hall, 1990
Vuchic Vukan R., Urban Transit: Operations, Planning and Economics, Prentice Hall, 2005.

CE 266 (AUG) 3:0

Pavement Engineering

Introduction to pavement engineering: Design of flexible and rigid pavements; selection of pavement design input parameters, traffic loading and volume, material characterization, drainage, failure criteria: pavement design of overlays and drainage system: pavement performance evaluation: non-destructive tests for pavement: IRC, AASHTO design codes: maintenance and rehabilitation of pavements

P Anbazhagan

Rajib B Mallick and Tahar El-Korchi, Pavement Engineering, Principles and Practice, CRC Press, 2009
Huang, Y.H, Pavement Analysis and Design, Prentice-Hall, New Jersey, 1993.

E. J. Yoder, M. W. Witczak, Principles of Pavement Design, Wiley New York, 1975.

CE267 (JAN) 3:0
Transportation Statistics and Micro-simulation

Role of statistics in transportation engineering; graphical methods for displaying transportation data; numerical summary measures; random variables in transportation; common probability distributions in transportation; use of sampling and hypothesis testing in transportation; use of ANOVA; regression models for transportation; Bayesian approaches to transportation data analysis; traffic micro-simulation models, analysing micro-simulation outputs, performance measures.

Ashish Verma

C. H. Spiegelman, E. S. Park, and L.R. Rilett, Transportation Statistics and Microsimulation, CRC Press, 2011.
J. R. Benjamin and C. A. Cornell, Probability, Statistics, and Decisions for Civil Engineers, McGraw-Hill Book Company, 1970.

CE 273 (JAN) 3:0
Fracture Mechanics

Definition of stress intensity factor. Fracture toughness. Energy release rate, critical energy release rate. Crack mouth opening displacement, R-curve. Elasto-plastic fracture mechanics and J-integral. Mixed-mode crack propagation, fatigue crack propagation. Computational fracture mechanics. Introduction to fracture of quasi-brittle materials like concrete, Non-linear fracture models with softening, Size effect in fracture of concrete.

J M Chandra Kishen

David Broek, Elementary Engineering Fracture Mechanics, Sijthoff and Noordhaff, Alphen Aan Den Rijn, The Netherlands.
Anderson, T. L., Fracture Mechanics: Fundamentals and Applications, CRC Press, USA, Second Edition.
Shah, S. P., Swartz, S. E. and Ouyang, C., Fracture Mechanics of Concrete: Applications of Fracture Mechanics to Concrete, Rock and Other Quasi-Brittle Materials, John Wiley and Sons, USA

CE 275 (JAN) 2:0
Nonlinear FEM in Structural Engineering

Concept of material, geometric, and contact nonlinearities. Review of continuum mechanics: stress and strain measures; balance laws. Review of continuum plasticity: rules for yield, flow, and hardening. Total Lagrangian and updated Lagrangian formulations for geometrically nonlinear solid continua. FE formulations for inelastic solids with linear/nonlinear strain-displacement relations. Thermo-mechanical analysis. Problems of structural dynamics. General solution techniques

C S Manohar

Pre-requisite:: Background in FEM and solid mechanics
T Belytschko, W K Liu, B Moran, and K I Elkhodary, 2014, Nonlinear finite elements for continua and structures, 2nd Edition, Wiley, Chichester.
J N Reddy, 2004, An introduction to nonlinear finite element analysis, Oxford University Press, New Delhi.
W F Chen and D J Han, 2008, Plasticity for structural engineers, J .Ross publishing / Cengage Learning, New Delhi.
J Bonet, and R D Wood, 2008, Non-linear continuum mechanics for finite element analysis, Cambridge University Press, Cambridge.

CE276 (JAN) 3:0
Structural Masonry

Masonry materials, Masonry characteristics, Compression failure theories, masonry in tension, shear and biaxial stress, Laterally loaded un-reinforced walls, Strength of masonry arches, Design of reinforced and un-reinforced masonry structures.

B V VENKATARAMA REDDY

Hendry, A. W., Structural Masonry, MacMillan Press, 1998

Current literature

CE 287 (JAN) 3:0
Stochastic Structural Dynamics

Introduction to random variables and processes: probability, random variables. Transformations of random variables. Stationary, ergodic and non-stationary stochastic processes. Linear transformation of stationary-ergodic stochastic processes. Normal Gaussian Stochastic processes. PSD functions. Wiener processes and an introduction to Ito calculus. Response of SDOF and MDOF oscillators under random inputs. Oscillators subject to white noise excitations. Input-output relations in time and frequency domains under the assumption of response stationarity. Handling non-stationarity in the response. level crossing and first passage problems. Nonlinear oscillators under random inputs: sources of non-linearity. Equivalent linearization and perturbation methods. Numerical integration and Monte Carlo simulations: Ito-Taylor expansions. Stochastic Euler and Heun methods. Higher order implicit and explicit methods. Errors in Monte-Carlo simulations. Variance reduction techniques.

D Roy

Lin, Y K, Probabilistic Structural Dynamics, McGraw-Hill
Kloeden, P.E. and Platen, E., Numerical Solutions of Stochastic Differential Equations, Springer
Ghanem, R.G and Spanos, P D, Stochastic Finite Elements: A Spectral Approach, Springer-Verlag.

CE 291 (JAN) 3:0
Uncertainty modelling 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

Applied Statistics and Probability for Engineers by Douglas C. Montgomery & George C. Runger, John Wiley and Sons, 2010
Selected works from the current literature will be given by the instructor

CE 294 (AUG) 3:0
Monte Carlo Simulations in Structural Mechanics

Review of probability and statistics. Pseudo-random numbers; tests for randomness; generation of scalar and vector random variables; transformation techniques; accept-reject method; Markov Chain, Monte Carlo, Review of random processes. Simulation of scalar and vector random processes; Fourier and Karhunen-Loeve expansions; filtered white noise models and SDE-s. Applications to structural reliability estimation. Variance reduction techniques; subset simulations; Girsanov transformation; Sequential Monte Carlo.

C S Manohar

Prerequisites: Background in theories of probability and random processes.
J.S. Liu, Monte Carlo strategies in scientific computing, Springer, New York, 2006.
P.E. Kloeden and E.Platen, Numerical solution of stochastic differential equations, Springer-Verlag, Berlin, 1992.
A.Papoulis,, Probability, random variables and stochastic processes, 3rd Edition, McGraw-Hill, New York. 1991.

CE 299 0: 22 Dissertation Project

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

Faculty

Chemical Engineering

ME programme Duration 2years 64 Credits		
Core: 17 Credits		
CH 201	3:0	Chemical Engineering Mathematics
CH 202	3:0	Numerical Methods
CH203	3:0	Transport Phenomena
CH 204	3:0	Thermodynamics
CH 205	3:0	Chemical Reaction Engineering
CH 206	1:0	Seminar Course
CH 207	1:0	Applied Statistics & Design of Experiments
Project: 32 Credits		
CH 299	0:32	Dissertation Project
Electives: A balance of 15 credits to complete the 64 credits of the M E programme, out of which a minimum of 9 credits are to be taken from the courses offered in the department.		

CH 201 (AUG) 3:0
Chemical 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. Laplace and Fourier transforms..

Prabhu R. Nott

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

CH 202 (AUG) 3:0
Numerical Methods

Basics of scientific computing, numerical errors, solution of linear algebraic equations, linear least squares, eigen values, eigen vectors, solution of nonlinear equations, optimization methods, nonlinear least squares, interpolation, numerical differentiation and integration, solution of ODEs – initial and boundary value problems, finite differences for PDEs

M Giridhar

Chapra, S.C. and Canale, R.P., Numerical Methods for Engineers, McGraw Hill, NY, 6th edition, 2010.
Gupta, S.K., Numerical methods for Engineers, New Age Publishers, India 2009.
Beers, K.J., Numerical Methods for Chemical Engineering, Cambridge Univ. Press, Cambridge, UK 2010.

CH 203 (AUG) 3:0
Transport Processes

Basic transport laws and transport properties; shell and differential balances; Navier-Stokes equations, equations of change for temperature and concentration in dilute systems; similarity of three transport processes; steady and unsteady transport, forced and natural convection; convective diffusion in dilute solutions; integral balances and connection to unit operations; boundary layer theory, turbulence.

V Kumaran

Bird, R.B, Stewart, W.E. and Lightfoot, E.N., Transport Phenomena, Wiley, 1994.
Denn, M.M, Process Fluid Mechanics, Prentice Hall, 1980.
Whitaker, S., Fundamental Principles of Heat Transfer, New York, Pergamon, 1997.

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

Tester, J.W., and Modell, M., Thermodynamics and its Applications, Third Edn, Prentice Hall, 1997.
Callen, H.B., Thermodynamics and an Introduction to Thermostatics, John Wiley & Sons, 1985.
McQuarrie, D.A., Statistical Mechanics, University Science Books, 2000.
Hill, T.L., An Introduction to Statistical Thermodynamics, Dover Publications, 1960.

CH 205 (JAN) 3:0
Chemical Reaction Engineering

Overview, review of background material. Differential and integral balances for homogeneous reactive systems. Ideal reactors: batch/CSTR/PFR. Uniqueness and
multiplicity of steady states, heterogeneous reactions and reactors, non-ideal reactors.

K Kesava Rao and Rahul Roy

Aris R., Elementary Chemical Reactor Analysis, Prentice-Hall 1969.
Schmidt, L.D., The Engineering of Chemical Reaction, Oxford, 1998
Froment G.F., Bischoff K.B., and Wilde, J.D., Chemical Reactor Analysis and Design, Wiley, 2011.

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.

K. Ganapathy Ayappa and Prabhu R Nott

CH 207 (JAN) 1:0
Applied Statistics and Design of Experiments

Introduction to probability and statistics; conditional probability; independence; discrete and continuous random variables and distributions; sampling distributions; confidence interval; application of parameter estimation and hypothesis testing: statistical inference for one sample and two samples; application of parameter estimation and hypothesis testing; statistical inference for two samples; analysis of variance; linear and non-linear regression; design of experiments; factorial experiments.

M Giridhar

Montgomery, D.C. and Runger, G.C., Applied Statistics and Probability for Engineers, 5th ed., John Wiley & Sons, New York, NY, 2011.
Montgomery, D. C., Design and Analysis of Experiments, 7th ed., John Wiley & Sons, New York, NY 2005

CH 235 (AUG) 3:0
Modeling in Chemical Engineering

Model development principles; classification of models; modeling of complex situations of interest to chemical engineers through lumped parameter models, continuum models, population balance models, stochastic models, Monte Carlo methods, network models, percolation concepts, and fractal analysis of complex geometries.

Sanjeev K Gupta

Lecture notes provided by instructor.

CH 236 (JAN) 3:0

Statistical Thermodynamics

Introduction to kinetic theory; statistical mechanics of ideal gases; classical mechanics; statistical kinetic theory; non-equilibrium thermodynamics; correlation functions; linear response theory; theory of Brownian motion; projection operator formalism; hydrodynamic fluctuations.

M S Ananth

Vincenti and Kruger, Introduction to Physical Gas Dynamics, Wiley 1966.
Hansen, J.B., and McDonald, I.R., Theory of Simple Liquids, Academic, 1990.
McQuarrie, D.A., Statistical Mechanics, Viva Books, 2003.

CH 237 (AUG) 3:0
Polymer Science and Engineering
Introduction, polymer classification, structure; various techniques of synthesis and their kinetics; structure and molecular weight determination; chemistry and applications of commercial plastics; thermodynamics and solution properties; solid state properties, viscoelasticity and rubber elasticity; polymer processing and rheology.

M Giridhar / P C Ramamurthy

Odian, G., Principles of Polymerization, McGraw Hill, 2nd Ed., 1981.
Dotson, N. A., Galvan, R., Laurence, R. L., Tirrell, M., Polymerization Process Modeling, Wiley, 1995.
Billmeyer, F. W., Textbook of Polymer Science, John Wiley & Sons, 1984.

CH 239 (JAN) 3:0
Modern Instrumental Methods of Analysis

Introduction to absorption and emission spectroscopy, ultraviolet and visible spectrophotometry, nephelometery, turbidance and reflectance methods, fluorescence and phosphorescence spectrophotometry; flame emission and atomic absorption spectrometry; inductively coupled plasma atomic emission spectrophotometry; IR spectrophotometry; X-ray techniques; introduction to NMR spectroscopy; electro-analytical techniques; voltametry, conductimetry, polarography; Karl Fischer moisture analysis gas analysis; chromatographic techniques such as, GC, LC and HPLC; process instruments and automatic analysis, errors and statistical methods of data handling.

J R Mudakavi

Willard, H., Meritt, L. L., Dean J. A. and Settle F.A. Instrumental Methods of Analysis, 6th edition, CBS, 1986
Vogel, A. I., Quantitative Inorganic Analysis, V Edition, ELBS, 1986.
Ewing, G. W., Analytical Instrumentation Hand Book, Marcel Dekker, New York, 1990

CH 242 (AUG) 3:0
Special Topics in Theoretical Biology

Motivation for theoretical studies of biological phenomena; reaction-diffusion systems; biological oscillations and chaotic systems; bacterial chemotaxis; interacting population dynamics; within-host dynamics of viral infections; virus-cell interactions; host immune response; drug pharmacokinetics and therapy; disease epidemiology; HIV and hepatitis C virus infections; tumor progression and cancer.

Narendra M Dixit

J. D. Murray, Mathematical biology I & II, Springer (3rd edition), 2003
R. M. May and R. M. Anderson, Infectious Diseases of Humans: Transmission and Control, Oxford, 1991
M. A. Nowak and R. M. May, Virus Dynamics: Mathematical Foundations of Immunology and Virology, Oxford, 2000

CH 243 (JAN) 3:0
Mechanics of Particle Suspensions

Forces acting on particles in a fluid-particle suspension; Flow regimes; Creeping flow: Fundamentals of Stokes flow, singularity solutions, and the fluid velocity disturbance due to an isolated particle; Inertial flow: fluid-particle and particle-particle interactions; Hydrodynamic interactions between suspended participles; Sedimentation, rheology and self-diffusion of dilute Stokesian suspensions; Dynamics of concentrated suspensions; Continuum description of suspensions using volume and ensemble averaging; Non-linear rheology and segregation; Applications to living cells and other biological systems.

Prabhu R Nott

Prerequisites: Post-graduate course in Fluid Mechanics

J. Happel and H. Brenner, Low Reynolds number hydrodynamics: With special applications to particulate media, Prentice-Hall, 1965
S. Kim and S. Karrila, Microhydrodynamics: Principles and selected applications, Dover, 2005
Roy Jackson, The dynamics of fluidized particles, Cambridge University Press, 2000

CH 244 (AUG) 3:0
Treatment of Drinking Water

Availability of water, contaminants and their effects on human health, quality standards. Removal of contaminants by various processes: chlorination, filtration, coagulation and flocculation, reverse osmosis, adsorption and ion exchange. Rainwater harvesting

K Kesava Rao

Droste, R.L., Theory and Practice of Water and Wastewater Treatment, Wiley (Asia), 2004
Sawyer, C.N., McCarty, P.L., and Parkin, G.F., Chemistry for Environmental Engineering and Science, Fifth Edn, Tata McGraw Hill, 2004.
Seader, J.D., and Henley, E.J., Separation Process Principles, Second Edn, Wiley-India, 2006.

CH 245 (JAN) 3:0
Computational Transport Phenomena

Review of conservation equations. Classical diffusive and convective transport solutions and population balances, species balance for multi-component and particulate systems. Stefan-Maxwell and other constitutive relations, similarities between various transport processes, mass transfer in concentrated solutions and high flux corrections, computational techniques for governing equations for transport processes in multi-component mixtures, ionic solutions, and particulate processes such nucleation, growth, aggregation, and breakup of particles. Current applications of these techniques.

K S Gandhi and Sanjeev K Gupta

Bird, R.B., Stewart, W.E., and Lightfoot, E.N., Transport Phenomena, Second Edn, John Wiley, 2002.
Fletcher, C.A.J., Computational Techniques for Fluid Dynamics, Vol. 1, Second Edn., Springer, 1991.
Taylor, R., and Krishna, R., Multicomponent Mass Transfer, John Wiley, 1993.

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

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

K. Ganapathy Ayappa and Sudeep Punnathanam

M. P. Allen and D. J. Tildesley, Computer simulation of Liquids, Oxford University Press, New York, 1987
D. Frenkel and B. Smit, Understanding Molecular Simulation: From Algorithms to Applications, 2nd Ed., Academic Press, San Diego, 2002

CH 248 (JAN) 3:0
Molecular Systems Biology

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

Rahul Roy

Course Notes:

The course is intended for Masters and PhD students. Undergraduates with sufficient background may approach the instructor regarding the course.
No prior knowledge of biology is needed but a non-biologist will have to self-educate.
Basic grasp of calculus, algebra and programming skills in C, Matlab or Mathematica is recommended.
Philip Nelson, Biological Physics: Energy, Information, Life, W. H. Freeman, 2007, ISBN-13: 978-0716798972.
Edda Klipp, Wolfram Liebermeister, Christoph Wierling, Axel Kowald, Hans Lehrach, Ralf Herwig, Systems Biology, Wiley-Vch, 2009, ISBN: 978-3527318742.
Uri Alon, An Introduction to Systems Biology: Design Principles of Biological Circuits, Chapman & Hall/CRC Mathematical & Computational Biology, 2006, ISBN: 978-1584886426.

CH 299 0:32
Dissertation Project

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

Faculty

Management Studies

Master of Management (M.Mgt) Program
Duration: 2 years

Hard Core: 24 credits
MG 201 3:0 Economics
MG 211 3:0 Human Resource Management
MG 212 2:1 Behavioral Science
MG 221 2:1 Applied Statistics
MG 232 3:0 Principles of Management
MG 241 3:0 Marketing Management
MG 251 3:0 Finance & Accounts
MG 261 3:0 Operations Management
Stream Core: 12 Credits (to be chosen from either one of the two streams)

Stream 1: Business Analytics Stream
MG 223 3:0 Applied Operations Research
MG 225 3:0 Decision Models
MG 226 3:0 Time Series Analysis and Forecasting
MG 265 2:1 Data Mining

Stream 2: Technology Management Stream
MG 271 3:0 Technology Management
MG 274 3:0 Management of Innovation and Intellectual Property

MG 281 3:0 Management of Technology for Sustainability
MG 298 2:1 Entrepreneurship for Technology Start-ups

Electives: 12 credits

Project:

MG 299 0:16 Management Project

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

MG 201 (AUG) 3:0
Economics

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

M H Bala Subrahmanya

Allen, Bruce et al: Managerial Economics: Theory, Applications, and Cases, WW Norton, 6th Edition, 2005.

Kishore G. Kulkarni and Edwin G. Dolan, Understanding Macroeconomics, Horizon Textbook Publishing, LLC, 4th Edition, 2007.
Wilkinson, Nick, Managerial Economics: A Problem-Solving Approach, Cambridge University Press, 2005.

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.

M H Bala Subrahmanya

Ministry of Finance: Economic Survey, Government of India, Recent Issues.
Froyen, Macroeconomics: Theories and Policies, Pearson Education, 2005.
Reserve Bank of India: Annual Reports.

MG 205 (JAN) 3:0
The Economics of Indian Cities

Introductory: Conceptualizing the economic dimensions of Indian cities, economic drivers of urbanization, rural-urban linkages, global linkages. Concept of resource cities, autonomy and uniformity in Indian cities, the economics of identity, trade unionism, fan clubs and other mass organizations. Villages within cities and the political economy of land. Urban poverty, housing in a high-cost urban environment, demand for urban transportation, supply of urban transportation. Economics of urban water supply, water and the privatization of public goods. Economics of urban energy, Economics of the urban environment, urban culture and its economics. Gender and the urban economy, Economics of urban security. The Indian policy framework: From decongesting cities to cities as engines of growth, financing the city: public institutions, private initiatives.

Faculty

Arthur O'Sullivan, Urban Economics, McGraw Hill Series in Urban Economics, 2008.
Edwin S Mills and Bruce W Hamilton, Urban Economics, Addison Wesley, 1997.
Sivaramakrishnan, K.C., Amitabh Kundu and Singh, B.N., Handbook of Urbanization in India, Oxford University Press, 2005.

MG 211 (JAN) 3:0
Human Resource Management

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

K B Akhilesh

DeCenzo and Robbins, Personnel and Human Resource Management, Prentice Hall, 1988.
Werther and Davis, Human Resources and Personnel Management, McGraw-Hill, 1996.
Beardwell and Holden, Human Resource Management, Macmillan, 1995.
Akhilesh and Nagaraj, HRM 2000, Wiley Eastern, 1990.

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

Luthans, F, Organizational Behaviour, McGraw-Hill, 1988.
Weiten, Wayne, Psychology Applied to Modern Life, Books/Cole, 1986.
Munn, N.L., et al., Introduction to Psychology, (3rd Edn.), Oxford and IBH Publishing Company, 1975.
Makin P., Cooper C. and Cox C., Organizations and the Psychological Contract, University Press, 1999

MG 213 (AUG) 3:0
Organizational Behavior

Organization - its characteristics, objectives (nature of goals, independence and interdependence), structure (size, centralization, formalization, standardization), process (decision making, leadership motivation, etc., authoritative vs participative styles), technology. Organization and its environment, power dynamics, conflict management, organizational learning and growth, organizational development, interventions at job, individual, group and organizational levels.

K B Akhilesh

Babbit, H.R. et al, Organizational Behaviour, Prentice Hall, New Jersey, 1978.
Osborn, R.N. et al, Organizational Theory, John Wiley, New York, 1980.
Gerloff, E.A., Organizational Theory and Design, McGraw-Hill 1985.
Child, J, Organizations, Harper and Row 1985.

MG 221 (AUG) 2:1
Applied Statistics

Brief introduction to probability theory and mathematical statistics. One and two sample problems for mean, variance and proportions – Z-test, t-test, X^2-test, F-test, Sign Test, Wilcoxon Rank–Sum and Signed-Rank test. X^2-test of homogenity, independence and goodness-of-fit. Introduction to design of experiments. Quantitative response with qualitative factors – one, two and multi-way analysis of variance; interaction effects; multiple comparisons. General analysis of quantitative response – simple and multiple linear regression modeling, hypotheses testing, and prediction; multiple and partial effects and correlations; residual analysis; dummy variable techniques (analysis of covariance).

Chiranjit Mukhopadhyay

Michael H. Kutner, Christopher J. Nachtsheim, John Neter & William Li, Applied Linear Statistical Models, McGraw-Hill International Edition, Fifth Edition, 2005.
C.R. Rao: Linear Statistical Inference and its Applications. Wiley. Second Edition.

MG 222 (AUG) 3:0
Advanced Analytics

Review of multiple linear regression - variable selection, regression diagnostics. Introduction to generalized linear models - likelihood inference, deviance, model checking.

Logistic regression - models for log-odds, estimation and hypothesis testing, residual analysis and goodness-of-fit, polytomous and ordinal responses, propensity scores.

Survival analysis - censored data, models and estimates for survival functions and hazard functions, proportional hazards and partial likelihood, semi-parametric models for regression, inference and model checking.

Multivariate ananlysis – multivariate Normal distribution and its properties, one two and multisample problem for multivariate Normal distribution, multivariate analysis of variance, principal component analysis, factor analysis.

Chiranjit Mukhopadhyay and Abinanda Sarkar

Hosmer David W. and Lemeshow Stanley. *Applied Logistic Regression*. Third Edition. 2013. Wiley.
Klein Jhohn P. and Moeschbergerer Melvin L. *Survival Analaysis: Techniques for Censored and Truncated Data*. Second Edition. 2003. Springer.
Johnson Richard A. and Wichern Dean W. *Applied Multivariate Statistical Analysis*. Sixth Edition. 2007. Pearson

MG 223 (JAN) 3:0
Applied Operations Research

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

M Mathirajan

Anderson, Sweeny, and Williams, An Introduction to Management Science: Quantitative Approaches to Decision Making, 11th Edition, South Western. 2005.
Taylor, Introduction to Management Science, 10th Edition, Pearson, 2010.
Hillier, Introduction to Management Science, 4th Edition, McGraw-Hill/Irwin. 2010.
Ravindran , A., Phillips, D.T. and Solberg J.J., Operations Research – Principles and Practice, 2nd Edition, 2000, John Wiley and Sons. 2000.

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

Saaty, T. L., The Analytic Hierarchy Process, McGraw-Hill, 1990.
Rardin, R. L., Optimization in Operations Research, Pearson, 2005.
Law, A. M. and Kelton, D. W., Simulation Modeling and Analysis, McGraw-Hill, 1991.
Mitchell, T., Machine learning, McGraw-Hill, 1997.

MG 226 (JAN) 3:0
Time Series Analysis and Forecasting

Classical decomposition of time series into trend, cyclical, seasonal and irregular components. Elementary trend modeling - growth models, polynomial and logistic trends. Stationary stochastic processes - auto-covariance and partial auto-correlation functions; MA, AR and ARMA models; forecasting. Stochastic trends – unit root tests, ARIMA modeling, forecasting. Frequency domain analysis – spectral density, periodogram, cycle discovery. Seasonality modeling – SARIMA models, forecasting. VAR models – stability, stationarity, impulse response analysis; forecasting.

Chiranjit Mukhopadhyay

Brockwell, Peter J & Davis, Richard A: Time series: Theory and methods. Springer series in Statistics. Second Edition.
Chatfield, Chris: Analysis of Time Series: An Introduction. Chapman and Hall. Sixth Edition.
Lutkepohl, Helmut: Introduction to Multiple Time Series Analysis. Springer-Verlag.

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

Harold Koontz and Heinz Weihrich, Essentials of Management – An International Perspective, Tata McGraw Hill Education Pvt. Ltd., New Delhi, 8th Edition, 2009.
Charles W.L. Hill, Steven L McShane, Principles of Management – Special Indian Edition, Tata McGraw Hill Education Pvt. Ltd., New Delhi, 2009.
Govindarajan M, and Natarajan S., Principles of Management, Eastern Economy Edition, PHI Learning Pvt. Ltd., New Delhi, 2009.

MG 241 (JAN) 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.

R Srinivasan

Phillip Kotler, Marketing Management - Analysis, Planning and Control, 13th Edition, Prentice-Hall of India, 2012.
R. Srinivasan, Case Studies in Marketing – The Indian Context, Prentice-Hall of India, 5th Edition, 2012.

MG 242 (AUG) 3:0
Strategic Management

Strategic management process, challenge of globalization, strategic planning in India. Corporate governance, board of directors. Role and functions of top management. Environmental scanning; industry analysis; internal scanning; organizational analysis. Strategy formulation: situation analysis and business strategy, corporate strategy, functional strategy, strategy implementation and control, strategic alternatives. Diversification, mergers and acquisition.

R Srinivasan

R. Srinivasan, Strategic Management – The Indian Context, Prentice-Hall of India, 4th Edition, 2012.
R. Srinivasan, Case Studies in Marketing – The Indian Context, Prentice-Hall of India, 5th Edition, 2012.

MG 243 (JAN) 2:0
International Marketing

Scope and size of international markets, conceptual framework, trade theories, institutional and policy framework, cultural environment for international business, political and legal environment, international markets - selection, market planning, control, product policy, market research, advertising, promotion, pricing and distribution.

R Srinivasan

R. Srinivasan, International Marketing, Prentice-Hall of India, 3rd Edition, 2008.
R. Srinivasan, Case Studies in Marketing – The Indian Context, Prentice-Hall of India, 5th Edition, 2012.

MG 244 (AUG) 3:0
Services Marketing

Basic issues, conceptual framework, service strategy, service design and mapping, perceived service quality. Customer satisfaction, product support services. Pricing. After service strategy, customer retention and relationship marketing. Service profitability and loyalty.

R Srinivasan

R. Srinivasan, Services Marketing, Prentice-Hall of India, 3rd Edition, 2012.
R. Srinivasan, Case Studies in Marketing – The Indian Context, Prentice-Hall of India, 5th Edition, 2012.

MG 251 (AUG) 3:0
Finance and Accounts

Nature and purpose of accounting, financial statements: learning, understanding the basic financial statements. Preparation of P and L account, balance sheet, basic accounts and trial balance. Income measurement, revenue recognition, depreciation accounting. Cash flow statements. Analysis and interpretation of financial statements; concepts and elements of cost, activity based costing. CVP analysis, break-even point, marginal costing, relevant costing.

Cost analysis for decision making: opportunity cost concept, dropping a product, pricing a product, make-or-buy and product mix decisions. Joint products, by-products. Process costing. Standard costing, budgeting – flexible budget, master budget, zero based budgeting.
Overview of Financial Management, time value of money, fund and cash flow statement, risk and return. Working capital management: estimating working capital, financing working capital, receivables management, inventory management, cash management, money markets in India.

Capital Budgeting: appraising long term investment projects, make vs. buy investment decisions, estimating relevant cash flow. Capital Structure: Estimation of cost of debt, cost of equity, overall cost of capital, CAPM. Capital structure planning: Capital structure policy and target debt equity structure, EBIT-EPS analysis. Leasing. Introduction to valuation of firm. Introduction to derivatives.

P. Balachandra

Anthony and Reece, Accounting Principles, AITBS, Sixth Edition, 1998
S.K. Bhattacharyya and John Dearden, Accounting for Management, Vikas Publishing House, Third Revised Edition, 1998.
Horngren, Foster and Dattar, Cost Accounting, PHI Publication, Tenth Edition.
Brearly R. and Myers S, Principles of Corporate Finance, McGraw-Hill, New Delhi, Fifth Edition.
Prasanna Chandra, Financial Management: Theory and Practice, Tata McGraw-Hill, Fifth Edition.

MG 261 (AUG) 3:0
Operations Management

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

M Mathirajan

Stevenson, William, J., Production/Operations Management. 6th Edition. Irwin/McGraw-Hill.
Krishnaswamy, K.N. and Mathirajan, M., Cases in Operations Management, Prentice-Hall of India Pvt. Ltd., New Delhi, 2008.
Heizer, J, and Render, B., Production and Operations Management – Strategies and Tactics, Allyn and Bacon.
Gaither N., and Frazier, G. Operations Management. 9th Edition, Cengae Learning India Pvt. Ltd. 2004.
Mahadevan, B. Operations Management: Theory and Practice, 2nd Edition, Pearson, 2007.

MG 265 (AUG) 2:1
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

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

MG 271 (JAN) 3:0
Technology Management

Definition of technology, technological transformation process, adaption. Adaption and innovation experiences in selected developed and developing countries. Technology transfer and its relation to technology transformation, diffusion and commercialization, rural technology management. Forward and backward integration. Some concepts in relation to technology management – productivity, employment, human resource and organizational development and corporate strategy. MOT scope and focus, measuring technology content and intensity, organizing the high technology enterprise. Concurrent engineering and integrated product development, managing technology based projects, technology evaluation and selection, leading technology teams.

K B Akhilesh

Thahaman, H.J., Management of Technology, New Jersey: John Wiley & Sons, 2005.
Betz Frederick, Strategic Technology Management, New York: McGraw Hill, 1994.
Day, G.S., Schoemaker, J.H.P., and Gunther, E.R., Wharton on Managing Emerging Technologies, New York: John Wiley & Sons, 2000.

MG 272 (AUG) 3:0
R & D Management

Strategic human resources; understanding and managing R&D personnel, selection, recruitment and human resource policies suitable for different kinds of establishments. Leadership, uncertainty, creativity and innovation; creative processes, group interaction, problem solving, organizational climate, team building. Individual, interpersonal and group factors, neurotic teams, organizational development, organizational structures and functioning, competence building at the individual, group and organizational levels.

Evaluation of R&D Projects; pre-initiation evaluation, need, risks associated with project selection.

K B Akhilesh

Hawthorne E.P., Management of Technology, McGraw-Hill, 1978.
Beattie, C.J. & Reader, R.D., Quantitative Management in R&D, Chapman and Hall, 1971.
Gibson J.E., Managing Research and Development, Wiley & Sons Inc., New York, 1983.

MG 274 (AUG) 3:0
Management of Innovation and Intellectual Property

Organizational and technological innovation – definition of innovation vs inventions, role of organizational design and processes – strategic role of intellectual property protection in case studies, the R&D value chain, stage gates, differences in priority with the R&D value chain, NPD - international, national, organizational, individual actors, organizations and vehicles to manage intellectual property, critical steps in managing R&D, process management during stage gates for patent searches, technology landscaping, specification writing, timeline management, rights and responsibilities in competitive technology environments, innovative inventions, commercial potential, processes to enhance technological know-how transfer, open source approach, incubators, assessing patent value, information technology support systems in managing innovation and intellectual property, prior art laboratories sessions and working with a client.

Mary Mathew

Trott, P., Innovation Management and New Product Development, Financial Times, Pitman Publishing, GB, 1998.
Petrusson, U., Intellectual Property and Entrepreneurship, Creating Wealth in an Intellectual Value Chain, CIP Working Paper Series, Centre for Intellectual Property Studies, Gotenburg, Sweden, 2004.
Rivette, K.G. & Kline, D., Rembrandts in the Attic, Unlocking the Hidden Value of Patents, Harvard Business School Press, Boston, Massachusetts, 2000.

MG 275 (JAN) 3:0
Knowledge Management for Innovation

Basics of knowledge management, related terminology, tacit and explicit knowledge, IT support systems, knowledge sharing culture and communication, classification approaches. Case of Apollo 11. Learning theory, measurement of learning, learning curve, measurement and contextualization of correct responses and errors in various technology situations such as technology “S” curves, maturation, decline, R&D investments, R&D project evaluation and R&D project termination, learning in sub systems, learning organization systems, learning from patent data. Management of knowledge in technological innovation and patent data. Classification of patent data and use in Knowledge Management. Patent price analysis. Technology domain analysis using patent and non patent literature. Indices of innovation potential, citations, science orientation, distance to market, crowdedness. Learning in the context of open innovation and open source.

Mary Mathew

Miller, W.L. and Morris, L., Fourth Generation R&D – Managing knowledge, Technology and Innovation, John Wiley and Sons, Inc, NY, 1999.

Parr, R.L. and Sullivan, P.H., Technology Licensing – Corporate Strategy for Maximizing Value, John Wiley and Sons, Inc, NY, 1996. Alan L. Porter

MG 276 (AUG) 3:0
Energy Policy

Introduction to concepts on energy sources, carriers and energy flows in the economy, issues in energy supply from both short and long term perspectives. Energy consumption from sectoral and end-use perspectives. Linkages between energy and economic development. Energy modeling,

energy economics, energy efficiency and renewable energy, interactions between energy and environment, integrated approaches to energy planning, energy policy instruments and institutions.

P Balachandra

Ristinen, R.A. and Kraushaar, J.J., Energy and the Environment, 2nd Edition, Wiley 2005.
Munashinghe, M., and Meier, P., Energy Policy Analysis and Modeling, Cambridge University Press, New York, 1993.
Goldenberg, J., Johansson, T.B., Reddy, A.K.N., and Williams, R.H., Energy for a Sustainable World, Wiley Eastern Ltd., New Delhi, 1988.

MG 277 (JAN) 2:0
Public Policy Theory and Process

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

Anjula Gurtoo

Weimer, D.L., and Vining A.R., Policy Analysis: concepts and practice, Prentice Hall, New Jersey, 2004.
Lindbhlom, C.E., and Woodhouse, E.J., The policy making process, Prentice Hall, 1993.

MG 281 (JAN) 3:0
Management of Technology for Sustainability

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

P Balachandra

Dorf, Richard C., Technology, humans, and society: toward a sustainable world, Academic Press, 2001.
Rogers, P.P., Jalal, K.F. and Boyd, J.A., An Introduction to Sustainable Development, Earthscan, London, 2007.
Weaver, P., Jansen, L., Grootveld, G.V., Spiegel, E.V. and Vergragt, P., Sustainable Technology Development, Greenleaf Publishing, Sheffield, 2000.

MG 283 (AUG) 3:0
Science & Technology Policy

Introduction to science, technology and society; sociology and politics; science and environment; religion and modernity; technology creation and diffusion; social and economic perspectives; ethics; life sciences and biotechnology (policy development and dynamics); genetics, nature and society; analytical frameworks: impact analysis and qualitative issues in research.

Anjula Gurtoo

Crow, M. (2000). Linking scientific research to societal outcomes. 25th AAAS Colloquium of Science and Technology Policy, held April, 11-13, Washington D.C.
Jasanoff, S., Markle, G. E., Petersen, J. C., and Pinch, T. J. (Eds.) .Handbook of Science and Technology Studies. Sage Publications, 1995.
Sismomdo, S. An Introduction to Science and Technology Studies, Edition 6, Wiley-**Blackwell Publishing.** 2008.
Williams, R. and Edge, D. The social shaping of technology. Research Policy Vol. 25, pp. 856-899, 1996.

MG 286 (AUG) 3:0
Project Management

The systems approach, project organization, work definition, scheduling and network analysis, PERT and CPM, resource–constrained scheduling, project costing and assessment, project control and management, software for project management, management of hi-tech projects, including software projects, quality and risk management.

Parameshwar P Iyer

Iyer, Parameshwar P., Engineering Project Management with Case Studies, Vikas Publishing, New Delhi, 2009.
Project Management Institute, USA. A Guide to the Project Management Body of Knowledge. Newton Square, PA. 1996.
Meredith, J.R., and Mantel, S.J. Jr., Project Management: A Managerial Approach, John Wiley and Sons, NY, 1995.

MG 298 (JAN) 2:1
Entrepreneurship for Technology Start-ups

Opportunity recognition, new product development, business models, marketing and positioning, business plans and financial requirements, finance and venture capital. The entrepreneurial team, managing strategy and innovation. IPR and contracts. Developing a personal entrepreneurship strategy.

Parameshwar P Iyer

Thomas W. Zimmer and Norman M. Scarborough, Essentials of Entrepreneurship and Small Business Management, Prentice Hall of India, New Delhi, 2005
Tom Peters., The Circle of Innovation, Alfred A. Knopf, New York, 1997.
John Drew., Readings in International Enterprise, Routledge, London, 1995.
Prem Vrat, K.K. Ahuja, and P.K. Jain., Case Studies in Management, Vikas Publishing House, New Delhi, 2002.

MG 299 (JAN) 0:16
Management Project

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

Faculty

MG 301 (AUG) 3:0
Methodology of Management Research

Nature of science and scientific thinking; The research process – specifics from various field of business and management; Research designs for various functional areas; Experimentation; Simulation; Theoretical modeling; Measurement and measurement errors; Sampling design; Hypothesis testing, Validation and reliability; Questionnaire design and data collection; Research Analysis; Statistical Analysis; Research and ethics; Report writing.

Mary Mathew & Anjula Gurtoo

Emory, C.W. & Cooper, D.R. 1991. Business research methods (4th ed.). Boston: Irwin.
Cooper, D. R. & Schnieder, P. 2010. Business Research Methods (11th ed.). UK: Tata McGraw Hill/Irwin.
Sekaran, U. 1992. Research methods for business: A skill building approach (2nd ed.). New York: John Wiley.

FOREIGN LANGUAGES

FL 141 (JAN) 3:0
Preliminary Course in Russian

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

Yadnyvalkya

Budoi, Bagga R.S. and Menon R.N. Russian Language, Russian Language Publishers, Moscow.

Mechanical Engineering

M E Programme
Duration: 2 years
64 credits

Hard Core: 19 credits

ME 201	3:0	Fluid Mechanics
ME 228	3:0	Materials & Structure Property Correlations
ME 240	3:0	Dynamics & Control of Mechanical Systems
ME 242	3:0	Solid Mechanics
ME 271	3:0	Thermodynamics
ME 297	1:0	Seminar Course
ME 261	3:0	Engineering Mathematics
		OR
MA 211	3:0	Matrix Theory
		OR
MA 251	3:0	Numerical Methods
		OR
PH 205	3:0	Mathematical Methods of Physics

OR
Any other course recommended by the department

Project: 27 Credits

ME 299 0:27 Dissertation Project

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

ME 201 (AUG) 3:0
Fluid Mechanics

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

J H Arakeri and R N Govardhan

Kundu, P.K., and Cohen, I.M., Fluid Mechanics, Elsevier, 2005. White, F.M., Fluid Mechanics, McGraw Hill, 1986.
Vennard, J.K., and Street, R.L., Elementary Fluid Mechanics, John Wiley, Sixth Edn. 1982.

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

Atomic structure of materials, atomic bonding, crystal structure point, line and areal defects in crystal structure, dislocation concepts of plastic deformation, critical resolved shear stress, interactions between dislocations and work hardening, fracture-microscopic descriptions, strengthening. Mechanisms of metals, processing maps, concepts of bio-materials. Natural and synthetics, fracture and fatigue of bio-materials.

Satish Vasu Kailas, M S Bobji and Narmrata Gundiah

Raghavan, V., Materials Science and Engineers, Prentice Hall, 1979.
Davidge, R.W., Mechanical Behaviour of Ceramics, Cambridge University Press, 1986.
Reed-Hill, R.E. and Abbaschian, R., Physical Metallurgy Principles, PWS-Kent Publishing Company, 1992.
Ratner B.D., Hoffman ,A.S., Schoen F. J., Lemons, J. E., Biomaterials Science- An introduction to Materials in Medicine, Academic Press 1996.

ME 237/ (AUG/JAN) 3:0
NE 211
Mechanics of Microsystems

An overview of micro-systems and micro-fabrication, mechanics issues relevant to micro- systems, scaling laws, materials properties and their role in micro-systems, lumped modeling of micro-systems. Coupled-simulations of multi-energy domain systems including electrostatics-mechanical, electro-thermal, thermo-mechanical, piezoelectric-mechanical, fluidic issues such as squeezed-film effects. Application of numerical techniques such as finite element and boundary element methods in solving steady-state and transient regimes. Case studies of selected micro-systems devices and systems. Introduction to biomechanics at the small sizes.

Rudra Pratap and G K Ananthasuresh

Pre-requisite: Multi-variable calculus and numerical analysis. No prior background in micro-systems or mechanics is assumed.
Senturia, S.D., Microsystem Design, Kluwer Academic Publishers, 2000.
Ananthasuresh, G K, et at. Micro and Smart Systems, Wiley-India, 2010

ME 238 (AUG) 3:0
Special Topics in Combustion

Review of combustion fundamentals – conservation equations, chemical kinetics, laminar premixed and diffusion flames, pollutant formation; combustion instability - basic concepts and mechanisms, acoustic-vortex-flame interactions, combustion instability and control, instability issues in industrial gas turbines and aero-engines; spray combustion, single component and multi-component droplet combustion; modeling of turbulent reacting flows, RANS and LES methods; laser diagnostic methods applied to reacting flows - PLIF, PIV, Raman, Rayleigh, LII, measurement of temperature, velocity, species and soot concentrations.

R. V. Ravikrishna, Saptarshi Basu

C. K. Law, Combustion Physics, Cambridge University Press, 2010
S. R. Turns, An Introduction to Combustion, Concepts and Applications, McGraw Hill International, Third Edition, 2012.
N. Peters, Turbulent Combustion, Cambridge University Press, 2006.
Katharina Kohse-Höinghaus and Jay Jeffries, Applied Combustion Diagnostics, Taylor and Francis, 2002.

ME 239 (JAN) 3:0
Modeling and Simulation of Dynamics Systems

Axioms of mathematical modeling, approximations and idealizations, fundamental balance laws, governing equations, state-space description, solution of ODEs, numerical methods for solutions of ODEs, explicit and implicit methods, error and accuracy, stability analysis of numerical solvers, stiff systems and stability, frequency domain in analysis of linear systems, FFT and power spectra, nonlinear systems, maps, bifurcations and chaos.

Rudra Pratap

Hirsh, M., and Smale, S., Differential Equations, Dynamical Systems and Linear Algebra, Academic Press, 1974. Farlow S.J., Partial Differential Equations for Scientists and Engineers, Dover Publications Inc., 1993.
Pratap, R., Getting Started with MATLAB 7, Oxford University Press, 2006.

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.

A Ghosal and Rudra Pratap

Greenwood, D.T., Principles of Dynamics, Second Edn., Prentice Hall, 1988.
Haug, E.J., Computer Aided Kinematics and Dynamics of Mechanical Systems, Vol. 1, Allyn and Bacon, 1989.
Franklin, G.F., Powell, J.D., and Abbas Emami-Naeini, Feedback Control of Dynamic Systems, Addison Wesley,1987.

ME 241 (JAN) 2:1
Experimental Engineering

Introduction to modeling of system response and sensor dynamics, Introduction to electronics, data acquisition and analysis, fluid velocity, stress, temperature measurement techniques. Experiments using photo-elasticity, universal testing machine, hot-wire anemometry, accelerometers.

S. Basu, Pramod Kumar, Namrata Gundiah

Doeblin, E.O., Measurement Systems: Application and design, McGraw Hill, 1990. Horowitz, P., and Hill, W., The art of electronics, Cambridge University Press, 1990.
Goldstein, R.J., Fluid mechanics measurements, Hemisphere Publishing Company, 1983.

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.

C S Jog and K R Y Simha

Fung, Y.C., Foundations of Solid Mechanics, Prentice Hall. Srinath, L.S., Advanced Mechanics of Solids, Tata McGraw Hill. Sokolnikoff, I.S., Mathematical Theory of Elasticity, Prentice Hall.

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.

C S Jog

Malvern, L.E., Introduction to the Mechanics of a continuous medium , Prentice Hall, 1969. Gurtin, M., An Introduction to Continuum Mechanics, Academic Press, 1981.
Hunter, S.C., Mechanics of Continuous Media, Ellis-Horwood, 1983.

ME 246 (JAN) 3:0
Introduction to Robotics

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

A Ghosal

Ghosal, A., Robotics: Fundamental Concepts and Analysis, Oxford University Press, 2006. Notes and recent research papers.

ME 248 (AUG) 3:0
Industrial Noise Control

Acoustic waves, sound pressure level, intensity level, power level and impedance. Physiology of the human ear and subjective response to SPL. Instrumentation for noise measurement and analysis, noise criteria, hearing damage risk and environmental noise level criteria. Mechanisms of noise radiation and outdoor sound propagation, sound power, its use and measurement, sound in enclosed spaces, partitions, enclosures, barriers and muffling devices, sound power and sound pressure level estimation procedures.

M L Munjal

Bies, D.A., and Hanson, C.H., Engineering Noise Control, Third Edn, Spon Press, London, 2003.
Irwin, J.D., and Graf, E.R., Industrial Noise and Vibration Control, Prentice Hall, Englewood Cliffs, 1979. Munjal, M.L., Acoustics of Ducts and Mufflers, Wiley -Interscience, NY, 1987.

ME 249 (JAN) 3:0
Fundamentals of Acoustics

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

V R Sonti

Kinsler, L.E., Frey, A.R., Coppens, A.B., and Sanders, J.V., Fundamentals of Acoustics, John Wiley, 1982. Williams, E., Fourier Acoustics

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.

V R Sonti

Pre-requisite: Consent of Instructor

Junger, M.C., and Feit, D., Sound, Structures and their Interaction, MIT Press, 1986.
Fahy, F.J., Sound and Structural Vibration, Academic Press, 1985.
Cremer, L., Heckl, M., and Ungar, E. E., Structure-Borne Sound, Springer-Verlag, 1987.

ME 251 (JAN) 3:0
Biomechanics

Bone and cartilage, joint contact analysis, structure and composition of biological tissues. Continuum

mechanics, constitutive equations, nonlinear elasticity, rubber elasticity, arterial mechanics. Introduction to cell mechanics.

Namrata Gundiah

Humphrey, J.D., Cardiovascular Solid Mechanics, Springer-Verlag, 2002. Fung, Y.C., Biomechanics, Springer-Verlag, 1990.
Holzapfel, G. A., Nonlinear Solid Mechanics, Wiley, 2000.

ME 252 (AUG) 3:0
Mechanisms

Simple and complex mechanisms, kinematic analysis by graphical and algebraic methods. Complex number, vector, quaternion, tensor-based kinematics. Computer aided kinematics, modeling constraints and simulation. Rigid body guidance problem. Curvature theory in plane kinematics. Elements of line geometry and screw theory for rigid body motion in space.

Dibakar Sen

Hirschhorn, J., Kinematics and Dynamics of Plane Mechanisms, McGraw Hill, 1962.
Haug, E.J., Computer Aided Kinematics and Dynamics of Mechanical systems, Allyn and Bacon. Hunt, K.H., Kinematic Geometry of Mechanisms, Clarendon Press.

ME 253 (JAN) 3:0
Vibrations of Plates and Shells

Shell coordinates, infinitesimal distances in curved shells, equations of motion for general shell structures using Hamilton's principle, specialization to commonly occurring geometries, detailed study of flat plates, rings, cylindrical shells and spherical shells, natural frequencies and modes, Rayleigh-Ritz and Galerkin methods, response to various types of loads (point forces, moments, moving loads), transient and harmonic loads, combination of structures using receptance.

V R Sonti

Pre-requisite: a full course in lumped system vibrations

Werner Soedel ,Vibrations of plates and shells
S.S. Rao Vibrations of continuous systems

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.

M S Bobji

Halling, J. (ed.), Principles of Tribology, Macmillan, 1975.
Seireg, A.A., Friction and Lubrication in Mechanical Design, Marcel Dekker, 1998. Cameron, A., Principles of Lubrication, Longman, 1966.

ME 256 (JAN) 3:0
Variational Methods and Structural Optimization

Calculus of variations: functionals, normed vector spaces, Gateaux variation, Frechet differential, necessary conditions for an extremum, Euler-Lagrange multiplier theorem, second variations and sufficient conditions. Weak form of differential equations, application of Euler- Lagrange equations for the analytical solution of size optimization problems of bars and beams, topology optimization of trusses and beams applied to stiff structures and compliant mechanisms. Material interpolation methods in design parameterization for topology optimization, optimization formulations

for structures and compliant mechanisms involving multiple energy domains and performance criteria. Essential background for Karush-Kuhn- Tucker conditions for multi-variable optimization, numerical optimization algorithms and computer programs for practical implementation of size, shape and topology optimization problems.

G K Ananthasuresh

Smith, D.R., Variational Methods in Optimization, Dover Publication, 1998.
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.

ME 257 (JAN) 3:0
Finite Element Methods

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

R Narasimhan

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

ME 258 (JAN) 3:0
Acoustics of Ducts and Mufflers

Acoustics of moving media, duct acoustics, analysis and synthesis of one dimensional acoustic filters, the exhaust process of reciprocating I.C. engines. Analysis of exhaust mufflers, finite wave analysis of exhaust systems, aero-acoustic characterization of engine sources. Finite element methods for mufflers, design of exhaust mufflers.

M L Munjal

Munjal, M.L., Acoustics of Ducts and Mufflers, Wiley-Interscience, NY, 1987. Goldstein, M.F., Aeroacoustics, McGraw Hill, 1976.

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 I-D plasticity and visco-plasticity. Return mapping algorithm. Continuum plasticity theory. Stress updated procedures. Treatment of incompressible deformation. Fundamentals of finite deformation mechanics-kinematics, stress measures, balance laws, objectivity principle. Finite element procedure for nonlinear elasticity. Lagrangian and spatial formulations. Finite element modeling of contact problems. Finite element programming. Newton-Raphson procedure. Finite element formulation for plasticity and nonlinear elasticity. Stress update algorithms for plasticity. Finite element modeling of contact problems – slide-line methods and penalty approach. Finite element programming.

R Narasimhan

Pre requisite: ME 257 or equivalent

Bathe, K.J., Finite Element Procedures, Prentice Hall of India, New Delhi 1997.
Zienkiewicz, O.C., and Taylor, R.L., The Finite Element Methods, Vols. I and II, McGraw Hill, 1991.
Belytshko, T., Liu, W.K., and Moran, B., Nonlinear Finite Elements for Continua and Structures, Wiley, 2000.

ME 260 (AUG) 3:0
Topology Optimization

Hierarchy in structural optimization: topology, shape, and size. Michelle continua and truss/frame topology optimization. Design parameterization and material interpolation: ground structure method, homogenization-based method, density distribution, level-set methods, peak function methods, phase-field methods. Numerical methods for topology optimization: optimality criteria methods, convex linearization and method of moving asymptotes, dual algorithms, numerical issues in the implementation of topology optimization algorithms, applications to multi-physics problems, compliant mechanisms and material microstructure design. Manufacturing constraints, other advanced topics.

G K Ananthasuresh

Pre-requisite: ME 256. Background in finite element analysis is preferred.

Bendsoe, M.P., and Sigmund, O., Topology Optimization: Theory, Methods, and Applications, Springer, 2003. Contemporary literature.

ME 261(AUG) 3:0
Engineering Mathematics

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

Gaurav Tomar and Ratnesh K. Shukla

Kryyzig E, Advanced Engineering Mathematics
C.R. Wylie, Advanced Engineering Mathematics
M.D. Greenberg, Advanced Engineering Mathematics
F. B. Hildebrand, Methods of Applied Mathematics
Bender and Orszag, Advanced Mathematical Methods for Scientists and Engineers"

ME 271 (AUG) 3:0
Thermodynamics

Concepts of thermodynamics, zeroth law, first law, properties of pure substances and mixtures, first order phase transitions, thermo-physical properties, energy storage, second law. Energy analysis of process and cycle, calculation of entropy and entropy diagrams, availability analysis, multi-phase multi-component systems, membrane equilibrium, phase equilibrium, chemical equilibrium.

Pradip Dutta, R V Ravikrishna, Pramod Kumar, S. Basu

Van Wylen, G.J., and Sonntag, R.E., Fundamentals of Classical Thermodynamics, Wiley. Wark, K., Advanced Thermodynamics for Engineers, McGraw Hill, 1995.

ME 272 (JAN) 3:0
Thermal Management of Electronics

Structures of heat in electronic systems, review of heat transfer mechanisms with reference to electronic systems: foot prints, spreading resistance, design of fins, convection and radiation from electronic modules, jet impingement cooling, active cooling systems – adsorption, thermo-electric, phase change: current state of the art and future projections of thermal needs in electronics.

P Dutta

Thermal Management of Electronic Systems, Vol. 1-4, ASME Press.

Krauss, A.D., and Cohen, A.B., Thermal Management of Electronics, Hemisphere. ASME Trans. Journal of Electronic Packaging IEEE Trans. on Components and Packaging Technologies.

ME 273 (JAN) 3:0
Solid and Fluid Phenomena at Small Scales

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

M S Bobji and R N Govardhan

Israelachvili, J.N., Intermolecular and Surface Forces, Elsevier Publishing Company, 2003.
Meyer, E., Overney, R.M., Dransfeld, K., et al., Nanoscience Firction and Rheology on the nanometer scale, 1998. Karniadakis, G.E., and Beskok, A., Micro Flows, Springer Verlag, 2001.

ME 274 (JAN) 3:0
Convective Heat Transfer

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

S Basu, P Dutta, Pramod Kumar

Pre-requisite: ME 201 and ME 271

Kays, W.M., and Crawford, M.E., Convective Heat and Mass Transfer, Tata-McGraw Hill. Bejan, A., Convective Heat Transfer, John Wiley.

ME 275 (AUG) 3:0
Radiative Heat Transfer

Black body radiation, radiative properties of non-black surfaces, Kirchoff's Law, radiative exchange between different surfaces, configuration factor, radiative transfer in enclosures, radiative transfer in gases, Planck and Rosseland mean coefficient, equation of transfer, gas radiation in enclosures and furnaces, interaction between conduction, convection and radiation.

V Srinivasan and P Dutta

Siegel, R., and Howell, J., Thermal Radiation Heat Transfer, Taylor and Francis, 2002. Hottel, H.C., and Sarofim, A.F., Radiative Transfer, McGraw Hill 1967.
Modest, M.F., Radiative Heat Transfer, McGraw Hill 1993.

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

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

P Dutta, R V Ravikrishna, Ratnesh Shukla, G Tomar

Pre-requisite: ME 201, ME 271

Patankar, S.V., Numerical Heat Transfer and Fluid Flow, Hemisphere Publishing Corporation, 1980.

Anderson, D.A., Tannehill J.C., and Pletcher, R.H., Computational Fluid Mechanics and Heat Transfer, Hemisphere Publishing Corporation, 1984.
Versteeg, H.K., and Malalasekara, W., An Introduction to Computational Fluid Dynamics, Longman, 1995.

ME 283 (AUG) 3:0
Two Phase Flows and Boiling Heat Transfer

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

Gaurav Tomar

Graham B Wallis, “One dimensional two phase flow”, McGraw Hill, 1969
R T Knapp, J W Daily, F G Hammit, “Cavitation”, McGraw Hill, 1970
R Clift, J R Grace and M E Weber, “Bubbles, drops and particles”, Dover, 1978
P de Gennes, F Brochard-Wyart and D Quéré, “Capillarity and wetting phenomena”, Springer, 2004
V P Carey, “Liquid-Vapor Phase-Change Phenomena”, Hemisphere Pub. Corp., 1992.

Pre-requisite: A course in fluid Mechanics.

ME 284 (JAN) 3:0
Applied Combustion

Thermodynamics and Thermochemistry, Chemical equilibrium, adiabatic flame temperature, Chemical kinetics, Constant pressure and constant volume fixed-mass reactors, well-stirred reactor, Plug-flow reactor, Conservation Equations, Laminar Premixed and Diffusion Flames, Droplet Combustion, Introduction to Turbulent Combustion, Combustion in Gasoline and Diesel Engines, Combustion Chamber Design, Pollutant Formation, Exhaust after-treatment, Advanced Engine Concepts, Gas Turbine Combustors – design requirements, stability and emissions.

R V Ravikrishna

An Introduction to Combustion, Stephen R. Turns, McGraw Hill, 2011.
Combustion Engineering, Kenneth W. Ragland and Kenneth M. Bryden, Taylor & Francis, 2011.
Heywood, J.B., Internal Combustion Engine Fundamentals, McGraw Hill Intl Edn, 1988.

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.

J H Arakeri / R N Govardhan

Sabersky, R.H., and Acosta, A., Fluid Flow: A First Course in Fluid Mechanics
Wilson, D.G., The Design of High Efficiency Turbomachinery and Gas Turbine, MIT Press, 1984.

ME 286 (AUG) 3:0
Numerical Methods for Partial Differential Equations

Fundamentals of numerical approximation, finite difference, finite volume, finite element, and spectral methods

for parabolic and elliptic problems, consistency, stability, convergence, Lax equivalence theorem, error analysis, Fourier approaches, high-order spatio-temporal discretizations, high resolution methods for conservation laws, operator splitting, fractional steps, projection method, Stokes solvers, boundary-integral formulations, immersed-boundary methods, level set and volume of fluid methods for interface problems.

R K Shukla

Pre requisite: Consent of Instructor

Morton, K. W. and Mayers, D. F., Numerical solution of partial differential equations, Cambridge University Press, 2005.
LeVeque, R. J., Finite volume methods for hyperbolic problems, Cambridge texts in applied mathematics. Cambridge University Press, 2002.
Ferziger, J. H. and Peric, M., Computational Methods for Fluid Dynamics, Springer, 1999.
Hesthaven, J., Gottlieb, S. and Gottlieb, D., Spectral methods for time dependent problems", Cambridge University Press, 2007.

ME 287 (JAN) 3:0
Refrigeration Engineering

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

G S V L Narasimham

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

ME 288 (JAN) 3:0
Air Conditioning Engineering

Properties of air-water mixtures, psychometric chart, air conditioning processes, enthalpy potential, cooling and dehumidifying coils, cooling towers, heat transfer in buildings, comfort air conditioning, cooling load calculations, air conditioning system, design of air delivery systems, clean rooms and laminar flow equipment, air conditioning controls, noise and vibration control in air-conditioned rooms.

G S V L Narasimham

Jones, W.P., Air Conditioning Engineering, Fifth Edn, Butterworth Heinemann, Oxford, 2001.
Croome, D.J. and Roberts, B.M., Airconditioning and Ventilation of Buildings, Second Edn, Pergamon Press, Oxford, 1981.
Haines, R.W., and Hittle, D.C., Control Systems for Heating, Ventilating, and Air Conditioning, Sixth Edn, Springer Science plus Business Media, Inc., NY, 2003.
ASHRAE Handbooks (SI Editions): HVAC Applications (2007), Systems and Equipment (2008), Fundamentals (2009).

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.

G S V L Narasimham

Kreith, F., and Kreider, J.F., Principles of Solar Thermal Engineering, McGraw Hill, 1978.
Duffie, J.A., and Beckman, W.A., Solar Engineering of Thermal Processes, John Wiley and Sons, 1991. Meinel, A.B., and Meinel, F.P., Applied Solar Energy.

ME 293 (AUG) 3:0
Fracture Mechanics

Evolution of fracture mechanics, elements of elasticity and plasticity. Energetics of fracture, energy release rate and stress intensity factor, mixed mode fracture mechanics. Dynamic fracture, nonlinear fracture mechanics J integral, elastic – plastic crack tips fields, J integral testing, J controlled crack growth and stability and engineering approach to plastic fracture, impact phenomena and fragmentation.

K R Y Simha and R Narasimhan

Broek D., Elementary Engineering Fracture Mechanics, North-Holland.
Kanninen, M.K., and Popelar, C.H., Advanced Fracture Mechanics Oxford, 1985. Anderson, T.A., Fracture Mechanics, Fundamentals and application, CRC Press, 1994. Simha, K.R.Y., Fracture Mechanics for Modern Engineering Design, Universities Press 2001.

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

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

B Gurumoorthy and Dibakar Sen

Piegl, L., and Tiller, W., The NURBS Book, Springer-Verlag, 1995.
Mantyla, M., An Introduction to Solid Modeling, Computer Science Press, 1988.
Carter, J.S., How Surfaces Intersect in Space – An Introduction to Topology, World Scientific, 1993. Fomenko, A.T., and Kunii, T.L., Topological Modeling for Visualization, Springer - Verlag, 1997.

ME 294 (AUG) 2:0
Applied Impact Mechanics of Solids

Appreciation of Impact Problems in Engineering, Impact Plasticity, Fracture, Comminution and Concussion; Elements of Elasto-dynamics, Vibration and Waves; Characteristics of Bulk P-and-S Waves in infinite media; Characteristics of Rayleigh Surface Wave; Reflection, refraction and absorption of stress waves; Dispersion, nonlinearity,(acousto-elasticity), searching for solitons.

K R Y Simha

Pre-requisite: ME 242 Solid Mechanics or Equivalent

Timoshenko, S, P, and Goodier, J.N. Theory of Elasticity, McGraw Hill, 1970
Simha, K R Y Fracture Mechanics for Modern Engineering Design Universities Press, 2001
Graff, K F., Wave Motion in Elastic Solids, Dover 1975

ME 297 (AUG/JAN) 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. A 'pass' in the course is obtained by attendance of at least 80%.

Faculty Coordinator

ME 298 (JAN) 3:0
Fluid Turbulence

Stability of fluid flows, transition to turbulence-introduction to turbulence, Reynolds averaged

equations, statistical description of turbulence, vorticity dynamics, similarity methods, turbulent shear flows, Rayleigh Benard convention, modeling and numerical methods.

JH Arakeri

Pre-requisite: Consent of Instructor

Tennekes H and Lumley J L, A First Course in Turbulence, MIT 1972
Pope S.B., Turbulent Flows, Cambridge, 2000

ME 299 0:24
Dissertation Project

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

Faculty

MATERIALS ENGINEERING

M. E. PROGRAMME
MATERIALS ENGINEERING
(Duration : 2 Years)
64 credits

Hard core (8 credits)

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

Soft core (9 credits): Any three out of the following eight courses

MT 203	3:0	Materials Design and Selection
MT 209	3:0	Defects in Materials
MT 220	3:0	Microstructural Design and Development of Engineering Materials
MT 231	3:0	Interfacial Phenomena in Materials Processing
MT 245	3:0	Transport Processes in Process Metallurgy
MT 252	3:0	Science of Materials Processing
MT 253	3:0	Mechanical Behaviour of Materials
MT 260	3:0	Polymer Science and Engineering – I

Project (32 credits)

MT 299 0:32 Dissertation Project

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

MT 201 (JAN) 3:0
Phase Transformations

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

C Srivastava

Prerequisites: Basic courses on crystallography, thermodynamics, phase diagrams and diffusion.

D.A. Porter. and K.E. Easterling: Phase Transformations in Metal and Alloys, Van Nostrand, 1981.
A.K. Jena, and M. Chaturvedi: Phase Transformations in Materials, Prentice-Hall, 1993.
A.G. Khachaturyan: Theory of Structural Transformation in Solids, John Wiley, 1983.
R.E. Reed-Hill and R. Abbaschian: Physical Metallurgy Principles, P.W.S-Kent, 1992.

MT 202 (AUG) 3:0
Thermodynamics and Kinetics

Classical and statistical thermodynamics, Interstitial and substitutional solid solutions, solution models, phase diagrams, stability criteria, critical phenomena, disorder-to-order transformations and ordered

alloys, ternary alloys and phase diagrams, Thermodynamics of point defects, surfaces and interfaces. Diffusion, fluid flow and heat transfer.

T A Abinandanan

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 203 (AUG) 3:0
Materials Design and Selection

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

A H Chokshi

M.F. Ashby: Materials Selection in Mechanical Design, 3rd edition (2005).
M.F. Ashby and D. Johnson: Materials and Design (2002).

MT 208 (JAN) 3:0
Diffusion in Solids

Fick's first and second law, Interdiffusion, Intrinsic diffusion and Integrated diffusion coeffiecient, Relation with tracer diffusion coefficient, Growth Kinetics, Matano-Boltzmann analysis, History and development of the Kirkendall effect, Darken analysis, Stable, unstable and multiple Kirkendall planes. Concept of velocity diagram construction, Role of the Kirkendall effect on morphogenesis, Physico-chemical approach.

A PAUL

P. Shewmon: Diffusion in Solids

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

S Karthikeyan

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-Interscience, 2005.
J.P. Hirth and J.L. Lothe: Theory of Dislocations, 2nd ed., Krieger, 1982.
A. P. Sutton and R. W. Balluffi: Interfaces in Crystalline Materials, 1st ed., Oxford Univ. Press, 1995.

MT 218 (AUG) 2:1
Modeling and Simulation in Materials Engineering

Importance of modeling and simulation in Materials Engineering. The modeling processs. Analytical and numerical approaches. Numerical solution of ODEs and PDEs. Atomistic modeling – *ab-initio* techniques and molecular dynamics. Monte Carlo methods – Kinetic MC and simulated annealing. Mesoscale modeling – microstructure modeling methods, phase field technique, dislocation dynamics, computational crystal plasticity. Introduction to multi scale modeling schemes. Review and overview of materials modeling methods – capabilities, limitations and applications.

Labs on Molecular dynamics, Monte Carlo method, Dislocation dynamics and Phase field techniques

A N Choudhury, S Karthikeyan and T A Abinandanan

A.B. Shiflet and G.W. Shiflet: Introduction to Computational Science: Modeling and Simulation for the Sciences, Princeton University Press, 2006.
D.C. Rapaport: The Art of Molecular Dynamics Simulation, Cambridge Univ. Press, 1995.
K. Binder, D. W. Heermann: Monte Carlo Simulation in Statistical Physics, Springer, 1997.
R. Phillips: Crystal, Defects and Microstructures – Modeling Across Scales, Cambridge Univ. Press, 2001.
K.G.F Janssens, D. Raabe, E. Kozeschnik, M.A. Miodownik, B. Nestler: Computational Materials Engineering: An Introduction to Microstructure Evolution, Elsevier Academic press, 2007.
A. P. Sutton and R. W. Balluffi: Interfaces in Crystalline Materials, 1st ed., Oxford Univ. Press, 1995.

MT 220 (JAN) 3:0
Microstructural Design and Development of Engineering Materials

This course will build on the fundamentals of phase stability, transformations, processing, solid state physics, and mechanical behavior to describe how engineering materials can be tailored to achieve desired properties through the control of composition, processing and microstructure. Two broad classes of materials will be covered. Thermo-structural materials will include aluminium and magnesium alloys, titanium and nickel base alloys, steels, composites, shape memory alloys and amorphous alloys. Functional materials will include hard and soft magnetic materials, families of semiconductors, optical materials and electronic ceramics. Common applications for these materials and current technological challenges and trends will be also be highlighted.

Subodh Kumar, D Banerjee, U Ramamurty

G. Lutjering and J.C. Williams: Titanium, Springer, New York
R.C. Reed: The Superalloys: Fundamentals and Applications, Cambridge University Press, UK.
H.K.D.H. Bhadeshia and R. Honeycombe: Steels: Microstructure and Properties, Butterworth-Heinemann, UK.
I.J. Polmear: Light Alloys: From Traditional Alloys to Nanocrystals, 4th ed, Butterworth-Heinemann, UK.
R.E. Hummel: Electronic Properties of Materials, Springer, New York.
D. Hull and T.W. Clyne: An Introduction to Composite Materials, Cambridge University Press.

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

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

S Subramanian

E. Matrijivic (Ed.): Surface and Colloid Science, Plenum, New York, 1982.
A.W. Adamson: Physical Chemistry of Surfaces, Wiley Interscience, New York, 1996.
J.S. Laskowski and J. Rolston (Ed.): Colloid Chemistry in Mineral Processing, Elsevier, New York, 1992.

MT 235 (AUG) 3:0
Corrosion Technology

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

K A Natarajan

M.G. Fontana: Corrosion Engineering, 3rd Edition, McGraw-Hill, N.Y., 1978.
Borenstein: Microbiologically Influenced Corrosion Handbook.

MT 241 (AUG) 3:0
Structure and Characterization of Materials

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.

R Ranjan

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

MT 243 (JAN) 0:2
Laboratory Experiments in Metallurgy

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

Faculty

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

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

G S Gupta

J. Szekely and N.J. Themelis: Rate Phenomena in Process Metallurgy, Wiley, New York, 1971
G.H. Geiger and D R Poirier: Transport Phenomena in Metallurgy, Addison-Wesley, 1980.
D.R. Gaskell: Introduction to Transport Phenomena in Materials Processing, 1991.
R.B. Bird, W.E. Stewart and E.N. Lightfoot: Transport Phenomena, John Wiley International Edition, 1960
F.M. White: Fluid Mechanics, McGraw Hill, 1994
Research articles

MT 248 (JAN) 3:0
Modelling and Computational Methods in Metallurgy

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

Prerequisite: Knowledge of transport phenomena, programming language

G S Gupta

J. Szekely and N.J. Themelis: Rate Phenomena in Process Metallurgy, Wiley, New York, 1971
B. Carnahan, H.A. Luther and J.O. Wilkes: Applied Numerical Methods, John Wiley, NY, 1969.
Research articles

MT 250 (AUG) 3:0
Introduction to Materials Science and Engineering

Compulsory for ME. students who do not have BE Metallurgy Compulsory for research students without materials background
Bonding, types of materials, basics of crystal structures and crystallography. Thermodynamics, thermochemistry, unary systems. Methods of structural characterisation. Thermodynamics of solid solutions, phase diagrams, defects, diffusion. Solidification. Solid-solid phase Transformations. Mechanical behaviour: elasticity, plasticity, fracture. Electrochemistry and corrosion. Band structure, electrical, magnetic and optical materials. Classes of practical material systems: metallic alloys, ceramics, semiconductors, composites

V Jayaram

W.D. Callister: Materials Science & Engineering, Wiley (India) 2007

MT 252 / PD 214 (JAN) 3:0
Science of Materials Processing

Fundamentals of Materials Processing: Deformation processing. Fundamentals and applications of plasticity, yielding, flow instability, drawability, anisotropy. Temperature and strain rate dependence. Thermally activated deformation, dynamic recovery and recrystallization. Modeling of materials processing-processing maps. Applications of deformation processing. Casting and Joining, Powder processing.

Satyam Suwas and Satish Vasu Kailas

W.A. Backofen: Deformation processing: Addision Wesley.
R.W. Cahn and P. Haasan (Editors): Processing of Metals and Alloys: Materials Science and Technology series,, Wiley VCH.
B.H. Amstead, P.F. Oswald. and M. Begeman: Manufacturing Processes, John Wiley, 1987.

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

Theory of Elasticity. Theory of Plasticity Review of elementary dislocation theory. Deformation of single and polycrystals. Temperature and strain rate effects in plastic flow - strain hardening, grain size

strengthening, solid solution strengthening, order hardening, precipitation hardening, dispersion strengthening. Strengthening by martensitic transformation, creep, fatigue and fracture.

Praveen Kumar

A. Kelly and R.B. Nicholson (Editors): Strengthening methods in crystals.
G.E. Dieter: Mechanical Metallurgy, McGraw-Hill, London (1988).

MT 255 (JAN) 3:0
Solidification Processing

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

A N Choudhury

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

MT 256 (JAN) 3:0
Fracture

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

V Jayaram

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

MT 260 (AUG) 3:0
Polymer Science and Engineering I

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.

P C Ramamurthy and M Giridhar

G. Odian: Principles of Polymerization. McGraw Hill. 2nd Edition.. 1981.
N.A. Dotson. R. Galvan. R.L. Laurence and M. Tirrell: Polymerization Process Modeling. Wiley. 1995.
F.W. Billmeyer: Textbook of Polymer Science, Wiley. 1984.

MT 261 (JAN) 3:0
Polymer Science and Engineering II: Organic Electronics

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

P C Ramamurthy

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 Press.
S-S. Sun and N. S. Sariciftci (Editors): Organic Photovoltaics - Mechanisms, Materials, and Devices, CRC Press.
D.A. Neamen: Semiconductor Physics and Devices Basic Principles, McGraw Hill.

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

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

S Bose

D.R. Paul and S. Newman: Polymer Blends, Vol 1&2 , Academic Press, 2000
L.A. Utracki: Polymer Alloys and Blends, Hanser, 2000
C. Chung: Introduction to Composites, Technomic, Lancaster, PA. 1998.
J. Summerscales and D. Short: Fiber Reinforced Polymers, Technomic. 1988
T.J. Pinnavia and G.W. Beall (Editors): Polymer-Clay Nanocomposites, Wiley, New York 2000.
P.M. Ajayan, L.S. Schadler and P.V. Braun: Nanocomposite Science &Technology, Wiley-VCH, Weinheim, 2003.

MT 271 (AUG) 3:0
Introduction to Biomaterials Science and Engineering

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

K Chatterjee

Ratner et al: Biomaterials science: An introduction to materials in medicine, 2nd edition, Elsevier Academic Press
Current Research Literature

MT 299 0:32
Dissertation Project

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

FACULTY

Product Design and Manufacturing

M Des Programme
Product Design and Engineering
Duration: 2 years

Core Courses: 36 credits from the following pool

PD 201 2:1	Elements of Design
PD-202 2:1	Elements of Solid and Fluid Mechanics
PD 203 2:1	Creative Engineering Design
PD 205 2:1	Materials, Manufacturing & Design
PD 207 1:2	Product Visualization, Communication and Presentation
PD 209 3:0	Product Planning and Marketing
PD 211 2:1	Product Design
PD 212 2:1	Computer Aided Design
PD 216 2:1	Design of Automotive Systems
PD 218 2:1	Design Management
PD 219 0:3	Mini Design Project
PD 229 0:3	Computer Aided Product Design
PD 231 2:1	Applied Ergonomics
PD 235 2:1	Mechanism Design
PD 239 0:3	Design and Society

Project: 16 Credits

PD 299 0:16 Dissertation Project

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

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.

J E Diwakar and Guest Faculty

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.

J H Arakeri and B Gurumoorthy

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

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

PD 205 (AUG) 2:1
Materials, Manufacturing and Design

Engineering materials, metals and their properties, uses, processing methods, design data and applications, selection criteria, manufacturing and processing limitations, comparative studies. Plastics and composites, types, classification, properties, processing techniques and limitation, selection of plastics for specific applications, finishing and surface coating for different materials.

Satish Vasu Kailas

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

PD 207 (AUG) 1:2
Product Visualization, Communication and Presentation

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

J E Diwakar

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 (JAN) 3:0
Product Planning and Marketing

Corporate strategy for product planning, Introduction to marketing, new strategies, market identification, segmentation and entry, strategies. Consumer response measurement, perceptual mapping, brand equity, strategic product positioning. Estimation of sales potential, product launching and product life cycle, advertising basics, services and processes. Fundamentals of consumer behaviour.

N V Chalapathi Rao

Philip Kotler, Marketing Management
Merle Crawford, C., New Product management
Luck, David J., and Rubin, Ronald S., Marketing Research
Schiffman and Kanuk, Consumer Behaviour

PD 211 (JAN) 2:1
Product Design

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

J E Diwakar and Guest Faculty

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

PD 212 (JAN) 2:1
Computer Aided Design

CAD – modeling of curves, surfaces and solids manipulation of CAD models, features based modeling, parametric/ variational modeling, product data exchange standards. Introduction to CAID, surfaces. Interfacing for production and tool design, photo rendering and scanning, 3D animation and morphing, studio exercise in virtual products and systems.

N V Chalapathy Rao and B Gurumoorthy

Zeid, I., CAD/CAM, McGraw Hill

PD 214 / MT 252 (JAN) 3:0
Science of Materials Processing

Design for manufacture, influence of materials, process and tooling on the design of components manufactured by metal casting, forming and joining, form design of components, Fundamentals of Materials Processing: Deformation processing. Fundamentals and application of plasticity, Yielding, Flow instability, drawability, anisotropy. Temperature and strain rate dependence, Thermally activated deformation, dynamic recovery and recrystallization, Modeling of materials processing-processing maps. Applications of deformation processing. Casting and Joining, Powder processing.

Satyam Suwas and Satish Vasu Kailas

W.A. Backofen, Deformation processing: Addision Wesley.
Processing of Metals and Alloys: Materials Science and Technology series, eds. R.W. Cahn and P. Haasan, Wiley VCH.
Amstead, B.H., Oswald. P.F., and Begeman, M., Manufacturing Processes, John Wiley 1987.

PD 215 (JAN) 2:1
Mechatronics

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

J E Diwakar and N S Dinesh

Kuo, B.C., D.C.Motors and Control systems, SRL Publishing Co., 1979.
Kuo, B.C., Step Motors and Control Systems, SRL Publishing Co., 1979.

PD 216 (JAN) 2:1
Design of Automotive Systems

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

Anindya Deb

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

PD 217 (AUG) 2:1
CAE in Product Design

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

Anindya Deb

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

PD 218 (AUG) 2:1
Design Management

Designers' perspective of the market, designers and psychological issues, perception, errors in perception, designers' sources of product features: projective techniques to acquire product feature databases. Designer in a team: human resources issues a designer must know, designer and competition, collaboration and conflict management, designer in an organization, designer as an entrepreneur, designers' knowledge on intellectual property.

Mary Mathew

Oakley, M. (Ed), Design Management – A Handbook of Issues and Methods, Blackwell Publication.

PD 219 (AUG/JAN) 0:3
Mini Design Project

A project involving either the redesign of an existing product or conceptualization of a new product, considering functional, materials and manufacturing, ergonomic, aesthetic and marketing aspects. Product detailing using CAD/CAID tools. Presentation to mockup level with complete documentation for purposes of fabrication.

Faculty

PD 221 (JAN) 2:1
Methodology for Design Research

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

Amaresh Chakrabarti

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

PD 229 (AUG/JAN) 0:3
Computer Aided Product Design

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

A Ghosal and B Gurumoorthy

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.

Rina Maiti and Dibakar Sen

Sanders and McCormick, Human Factors in Engineering and Design, Seventh Edn, McGraw Hill, 1992.
Eberts, R.E., User Interface Design, Prentice Hall, 1994.

PD 235 (JAN) 2:1
Mechanism Design

Machines and mechanisms, links, pairs, degrees of freedom, kinematic chain, inversions. Kinematic analysis of simple mechanisms by graphical and analytic methods, static force analysis. Dimensional synthesis of four bar mechanism, application of coupler curves for dwell mechanisms, two and three position rigid body guidance. Cams, displacement curves and profile generation. Gears, profiles, cycloidal and involute, contact ratio. Spur, bevel, helical, worm gearing. Analysis of gear trains, mechanisms for specific functions.

Dibakar Sen and J E Diwakar

Sandor, G.N., and Erdman, A.G., Advanced Mechanism Design, Volumes I & II, Prentice Hall of India Limited, New Delhi.
Hirschhorn, J., Kinematics and Dynamics of Plane Mechanisms, McGraw-Hill, 1962
Mabie, H.E., and Ocvirk, F.W., Mechanisms and Dynamics of Machinery, John Wiley and sons, New York.
Current Literature

PD 239 (AUG/JAN) 0:3
Design and Society

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

Faculty

PD 299 (JAN) 0:16
Dissertation Project

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

Faculty

Sustainable Technologies

ST 201 (JAN) 3:0
Thermochemical and biological energy recovery from biomass

Biomass and its properties relevant for conversion processes. Thermochemical energy conversion processes and devices – stoves, combustors and gasifiers for heat, power and co-generation applications. Biological conversion techniques, processes and reactors. Efficiency, emissions. performance of end use devices and resource recovery options.

S Dasappa and H N Chanakya

Borman, G.L. and Ragland, K.W., Combustion Engineering, McGraw-Hill International Editions, Mechanical engineering series.
HS Mukunda, Understanding clean energy and fuels from biomass, Wiley India
Relevant papers from current literature.

ST 202 (AUG) 3:0
Energy Systems and Sustainability

Basics of energy resources and systems, renewable energy technologies, climate change and sustainability, climate change mitigation options and low carbon future, energy technologies, economics, policies and programmes. Case studies on renewable energy projects.

S Dasappa and P Balachandra

M. M. El-Wakil, Power Plant Technology, McGraw Hill.1984.
Aldo Vieira Da Rosa, Fundamentals of Renewable Energy Processes , Elsevier, 2009.
Boyle, G., Everett, B. and Ramage, J., Energy Systems and Sustainability: Power for a Sustainable Future, Oxford University Press, Oxford, UK, 2003.
Cassidy, E., and Grossman, P., Introduction to Energy Resources, Cambridge University Press, 1998.
IPCC, Renewable Energy Sources and Climate Change Mitigation - Special Report of the Intergovernmental Panel on Climate Change (IPCC), Cambridge University Press, New York, 2012, http://srren.ipcc-wg3.de/report/IPCC_SRREN_Full_Report.pdf.
Current literature

ST 203 (AUG) 3:0
Technology and Sustainability

Development, progress and sustainability: definitions, dimensions, interpretations, concepts, principles and indicators. Current issues and debates (case studies and assignment). Technology and Design: fundamentals, morphology, integrated life-cycle perspective. Appreciating design effectiveness, it's scientific, engineering and technological context. A systems view into social, environmental and economic implications delineating sustainability (& indicators) attributed to design/technology. Developing an integrated sustainability evaluation and forecasting model, and identification of appropriate interventions (mini-project & presentation).

Monto Mani

Bell, S., and Morse, S., Sustainability Indicators: Measuring the Immeasurable? Earthscan Publications, London, 2008.
Elliott, J.A., An Introduction to Sustainable Development, Routledge, New York, 2002.
Mani, M., Ganesh, L.S., and Varghese, K., Sustainability and Human Settlements: Fundamental Issues, Modeling and Simulations, Sage Publications, New Delhi, Thousand Oaks, London, 2005.
Meadows, D.H., Thinking in Systems: A Primer, Chelsea Green Publishing Company, White River Junction, VT, 2008.
Papanek, V., Design for the Real World. Academy Chicago Publishers, Illinois, 2000.
Technology Management Newsletter: www.techmotivator.iitm.ac.in

ST 204 (AUG) 1:1
Sustainable Energy and Environment lab

Energy conversion technologies, building comfort studies, water quality, building technologies

S Dasappa, Monto Mani, H N Chanakya, H I Somashekar and B V Venkatarama Reddy

Current literature.

ST 205 (AUG) 2:0
Conservation and Management of Biodiversity of Aquatic Ecosystems

Assessment, management and remediation of aquatic ecosystems. Community ecology of freshwater ecosystems. Biotic and abiotic factors that influence the structure of aquatic communities. Biodiversity monitoring and bioindicators. Ecology of estuary and marine biota. Conservation and management of fresh water and marine biodiversity. Principles of marine ecology. Assessment of coastal and estuary ecosystems and principals of coastal management and aquaculture. Estuary and marine pollution management systems. Socio-economic problems of aquatic pollution. Policies and legal aspects coastal ecosystem management. Environmental toxicology. Case studies on threats to the biodiversity of aquatic ecosystems.

D S Durgappa

Kungolos, A.G., Brebbia, C.A., and Zamorano, M., Environmental Toxicology, WIT Press, UK, 2007.
Conti, M.E., Biological Monitoring, WIT Press, UK, 2007.
Sharma, B.K, Water Pollution, Geol Publishing House, Meerut, 2001.

ST 206 (Jan) 2:1
Environmental and Natural Resources Management

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

T V Ramachandra

Kulkarni, V., and Ramachandra, T.V., Environmental Management, Capital Publishers, New Delhi, 2006.
Lo, C.P., and Yeung, A.K.W., Concepts and Techniques of GIS, Prentice Hall of India Private Limited, New Delhi, 2002.
Kanholm, J., EMS Manual, 21 Procedures and Forms, AQA Press, USA, 2000.
Holling, C.S., Adaptive Environmental Assessment and Management, John Willey & Sons, New York, 1987.
Meadows, D.H., Meadows, D.L., and Randers, J., Beyond the Limits – Global Collapse or Sustainable Future, Earth Scan Publications Limited, London, 1992.

ST 207 (JAN) 3:0
Alternate Fuels for Reciprocating Engines

Internal combustion engine classification, operating cycles, performance of spark ignition and compression ignition engines. Properties of various liquid and gaseous fuels. Combustion characteristics and performance of these fuels in engines – power output, efficiency and emissions.

S Dasappa

Heywood, J., Internal Combustion Engine Fundamentals, McGraw Hill Publication
Journal papers – SAE,IMechE – journal of power and energy, Automobile Engineering,
Current literature.

ST 209 (JAN) 2:0
Society and Technology

Understanding of technology for engineers, societal perspectives of technology, bridging the gap in understanding, overcoming conflicts in embedding technology in society, communicating technology, engaging in conversations and dialogue that help embed technology, planning sustainability into communicating technology, understanding existing perspectives of sustainability, merging it with the technical perspectives of sustainability, evolving communication that works for sustainable technologies, writing short texts and messages, peer group testing.

H N Chanakya and Anjula Gurtoo

Alley, M., The Craft of Scientific Presentations, Springer-Verlag, New York, Inc., 2003.
Changing the Conversation: Messages for Improving Public Understanding of Engineering. Committee on Public Understanding of Engineering Messages. National Academy of Engineering. The National Academies Press, Washington,D.C, **www.nap.edu** , 2008.
Diamond, J., Guns, Germs and Steel, W.W. Norton, 1997
Felt, U., The social and cultural tailoring of scientific knowledge in the public space, in M.E. GONCALVES (ed), Cultura cientifica e participaçao pública (Lisboa: Bertrand), 1999.
Ramakrishnan, P.S., Ecology and Sustainable Development – Working with knowledge systems, National Book trust, India, 2001.

ST 210 (AUG/SUM) 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.

T V Ramachandra

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**,** Oxford University Press.

ST 211(AUG) 3:0
Engineered Waste Management

Environmental laws and regulations, physio-chemical properties of soil, ground water flow and contaminant transport, contaminated site characterization, estimation of landfill quantities, landfill site location, design of various landfill components such as liners, covers, leachate collection and removal, gas generation and management, ground water monitoring, end uses of landfill sites, risk assessment approaches, remediation technologies.

G L Sivakumar Babu

Robert M., Brachman, Richard W. I., and Booker, John R., Barrier Systems for Waste Disposal Facilities , 2nd ed.,. Spon Press, Taylor & Francis Group, London, 2004
Rowe, R. Kerry, Quigley, Sharma, H.D., and Reddy, K.R., Geo environmental Engineering: Site Remediation, Waste Containment and Emerging Waste Management Technologies, John Wiley & Sons, Inc., Hoboken, New Jersey, 2004.
Tchobanoglous, Theisen and Vigil, Integrated Solid Waste Management - Engineering Principles and Management Issues, McGraw Hill,1993.

Supercomputer Education and Research Centre

M Tech Programme
Duration: 2 years
64 credits

28 Credits

SE 284 2:1 Numerical Linear Algebra
SE 286 2:1 Data Structures and Programming
SE 288 3:1 Numerical Methods
SE 289 3:1 Numerical Solutions of Differential Equations
SE 290 3:0 Modelling and Simulation
SE 292 3:0 High Performance Computing
SE 294 3:1 Data Analysis and Visualization
SE 295 3:1 Parallel Programming

24 Credits

SE 299 0:24 Dissertation Project

The balance of credits to make up the minimum of 64 required for completing the programme (all at 200 level or higher).

SE 250 (AUG) 3:1
Multigrid Methods

Classical iterative methods, convergence of classical iterative methods, Richardson iteration method, Krylov subspace methods: Generalized minimal residual (GMRES), Conjugate Gradient (CG), Bi-CG method. Geometric Multigrid Method: Grid transfer, Prolongation and restriction operators, two-level method, Convergence of coarse grid approximation, Smoothing analysis. Multigrid Cycles: Vcycle, W-cycle, F-cycle, convergence of multigrid cycles, remarks on computational complexity. Algebraic Multigrid Method: Hierarchy of levels, Algebraic smoother, Coarsening, Interpolation, remarks on parallel implementation.

Sashikumaar Ganesan

Prerequisites: Good knowledge of Linear Algebra and/or consent from the instructor.

Pieter Wesseling, An Introduction to Multigrid Methods, R.T. Edwards, Inc., 2004.
William L. Briggs, Van Emden Henson and Steve F. McCormick, A Multigrid Tutorial, SIAM, 2nd edition, 2000.

SE 260 (JAN) 3:0
Medical Imaging

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

medicine (PET/SPECT), multi-modal imaging, PET/CT, SPECT/CT, oncological imaging, medical image processing and analysis, image fusion, contouring, segmentation, and registration.

P K Yalavarthy

Prerequisites: Basic knowledge of system theory and Consent from the instructor.

Bushberg, J.T., Seibert, J.A., Leidholdt, E.M. Jr., and Boone, J.M., The Essential Physics of Medical Imaging, Second Edn, Lippincott Williams and Wilkins Publishers, Philiadelphia, 2002.
Wolbarst, A.B., Physics of Radiology, Second Edn, Medical Physics Publishing, Madison, WI, 2005.
Current Literature

SE 261 (AUG) 2:1
Numerical Methods in Biomedical Engineering

Modeling biosystems, role of computers in biomedical engineering, linear biological systems, simultaneous linear algebraic equations, Gaussian-elimination, iterative methods, examples: force balance in biomechanics and biomedical image processing, non-linear biological systems, Newton's method for simultaneous non-linear equations, examples: friction factor in catheter and receptor-ligand dynamics, dynamical biosystems, Eigenvalue methods, numerical stability, examples: pharmacokinetics: the drug absorption problem and laser ablation, basics of numerical solutions of ordinary differential equations (ODE), finite difference schemes for solving partial differential equations, initial and boundary conditions, Applications: modeling of glucose regulation, diabetes and insulin regulation, motion of rigid body, analysis of mass-spectra data, and separating EEG frequency components.

P K Yalavarthy

Prerequisites: Basic knowledge of numerical analysis along with basic MATLAB programming background and/or consent from the instructor.

Dunn, S.M., Constantinides, A., and Moghe, P.V., Numerical Methods in Biomedical Engineering, Academic Press, 2006.
Semmlow, J., Circuits, signals and systems for bioengineering, Academic Press, 2005.
Current Literature.

SE 263 (AUG) 3:1
Video Analytics

Introduction to Digital Image and Video Processing, Background Modeling, Shadow Removal, Invariant Image Representation, Object Detection and Recognition, Image and Motion Features, Multi Object Tracking, Trajectory Analysis, Recognition of Human Biometrics, Activities and Events, Anomaly Detection, Compressed Domain Video Analytics, Multi Camera Surveillance, Camera Coordination, Distributed Multi-Sensor Surveillance, Video Indexing, Mining and Retrieval.

R. Venkatesh Babu

Prerequisites: Basic knowledge of Image Processing.

Richard Szeliski, Computer Vision: Algorithms and Applications, Springer 2010
Forsyth, D.A., and Ponce, J., Computer Vision: A Modern Approach, Pearson Education, 2003.
Omar Javed, Mubarak Shah, Automated Multi-Camera Surveillance: Algorithms and Practice, Springer, 2008.
Current Literature

SE 284 (AUG) 2:1
Numerical Linear Algebra

Matrix Analysis: Vector and matrix norms, orthogonality, Singular Value Decomposition, projections, CS Decomposition. Solution of equations: Gaussian Elimination, pivoting, LU and Cholesky factorizations, LDM' and LDL' factorizations, positive definite systems, banded systems, block systems, Vandermonde systems and the FFT, Toeplitz systems. Orthogonalization and Least Squares: Householder and Givens Matrices, QR factorizations, Full Rank Least Squares(LS) Problem, Rank Deficient LS Problem. Unsymmetric Eigenvalue problem: power methods, Hessenberg and real Schur Forms, invariant subspace computations, QZ method. Symmetric Eigenvalue Problem: power iterations, symmetric QR algorithm, Jacobi methods, tridiagonal methods, SVD, Lanczos and Arnoldi methods. Iterative methods for linear systems: Jacobi and Gauss-Seidel iterations, SOR methods, Conjugate Gradient method, Preconditioned Conjugate Gradients. Sparse matrix methods: ordering, symbolic factorization, numerical factorization, triangular solvers, multifrontal method, iterative methods.

Murugesan Venkatapathi, P.K.Yalavarthy

Lloyd N. Trefethen and David Bau, III,Numerical linear algebra, SIAM, 1997.
C. G. Cullen, An Introduction to numerical linear algebra, Charles PWS Publishing, 1994.
Golub, G., Van Loan C.F., Matrix Computation, John Hopkins, 1996.
Saad, Y., Iterative Methods for Sparse Linear Systems, Second Edition, SIAM, 2003

SE 286 (AUG) 2:1
Data Structures and Programming

Time and space complexity. Elementary data structures: Arrays, Stack, Queues, Heaps, Priority Queues, Vectors and Sparse Matrices and related algorithms. Usage and concepts of frequently used sorting, searching, merging, Hashing Techniques. Introductory graph algorithms, trees including AVL, B+, Red-Black Trees, Tries and Suffix trees: usage and application, Usage/Application of String Algorithms. Introduction to Greedy Algorithms, introduction to Spatial Data Structures.

R Venkatesh Babu, Sathish Vadhiyar

Cormen, T.H., Leiserson, C.E., and Rivest, R.L., Introduction to Algorithms, The MIT Press and McGraw-Hill Book Company. (Indian Edition Available)
Stroustrup, B., C++ Programming Language, Addison Wesley. (Indian Edition Available)
Sahni Sartaj K., Data Structures, Algorithms, and Applications in C++, McGraw Hill.
Kruse, R.L., and Tondo, C.L., Data Structures and Program Design, Prentice Hall of India 1997.
Aho, A.V. Hopcroft and Ulman, J.D., Data Structurs and Algorithms.
Heilerman, G.L., Data Structures, Algorithms and Object oriented Programming, McGraw-Hill Intl Edn, 1996.
Samet Hanan, The Quadtree and Related Hierarchical Data Structures, ACM Computing Surveys, Vol.16-2, pp.187-229, 1986.

SE 288 (AUG) 3:1
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.

P.K.Yalavarthy

Richard L. Burden and J. Douglas Faires, Numerical Analysis: Theory and Applications, India Edition, Cengage Brooks-Cole Publishers, 2010.
Press, W.H., Teukolsky, S.A., Vetterling, W.T., and Flannery, B.P., Numerical Recipes in C/FORTRAN, Prentice Hall of India, New Delhi, 1994.
Krishnamurthy, E.V., and Sen, S.K., Numerical Algorithms, Affiliated East-West Press, New Delhi, 2001.
Borse, G.J., Numerical Methods with MATLAB: A Resource for Scientists and Engineers, PWS Publishing Co., Boston, 1997.

SE 289 (JAN) 3:1
Numerical Solutions of Differential Equations

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

A Mohanty

Arfken, G.B., and Weber, H.J., Mathematical Methods for Physicists, Sixth Edition, Academic Press, 2005.
Press, W.H., Teukolsky, S.A., Vetterling, W.T., and Flannery, B.P., Numerical Recipes in C/FORTRAN – The art of Scientific Computing, Second Edn, Cambridge University Press, 1998.
Lynch, D.R., Numerical Partial Differential Equations for Environmental Scientists and Engineers – A First Practical Course, Springer, New York, 2005.

SE 291 (JAN) 2:1
Finite Elements: Theory and Algorithms

Generalized (weak) derivatives, Sobolev norms and associated spaces, inner-product spaces, Hilbert spaces, construction of finite element spaces, mapped finite elements, two- and three-dimensional finite elements, variational formulation of second order elliptic boundary value problems, finite element algorithms and implementation for two-dimensional stationary incompressible Navier-Stokes equations.

Sashikumaar Ganesan

Prerequisites: Good knowledge of numerical analysis along with basic programming background and/or consent from the instructor.

Dietrich Braess, Finite Elements: Theory, Fast Solvers, and Applications in Solid Mechanics, Cambridge University Press, 3rd ed., 2007.
Susanne C. Brenner, Ridgway Scott, The Mathematical Theory of Finite Element Methods, Springer-Verlag, 3rd ed., 2008.
Current literature

SE 292 (AUG) 3:0
High Performance Computing

Introduction to Computer Systems: Processors, Memory, I/O Devices; Cost, timing, and scale (size) models. Program Execution: Process, Virtual Memory, System Calls, Dynamic Memory Allocation. Machine-Level View of a Program, typical RISC instruction set and execution, Pipelining. Performance issues and Techniques, Cost and Frequency Models for I/O, paging, and caching. Temporal and spatial

locality. Typical Compiler Optimizations. Identifying program bottlenecks – profiling, tracing. Simple high-level language optimizations – locality enhancement, memory disambiguation. Choosing Appropriate Computing Platforms: benchmarking, cost-performance issues, etc. Parallel Computing: Introduction to parallel Architectures and Interconnection Networks, communication latencies. Program parallelization: task partitioning and mapping, data distribution, Message passing, synchronization and deadlocks. Distributed memory programming using MPI/PVM. Shared memory parallel programming. Multithreading.

R Govindarajan, Yogesh Simmhan

Dowd, K., High performance Computing, O'Reilly Series, 1993.
Culler, D., and Singh, J.P., Parallel Computer Architecture: A Hardware/Software Approach. Morgan Kaufmann Pub., 1999.
Gropp, W., Lusk, E., and Skjellum, A., Using MPI: Portable Parallel Programming with the Message-passing Interface, MIT Press, 1997.

SE 294 (JAN) 3:1
Data Analysis and Visualization

Data pre-processing, data representation, data reconstruction, visualization pipeline, isosurfaces, volume rendering, vector field visualization, applications to biological and medical data , OpenGL, visualization toolkit, linear models, principal components, clustering, multidimensional scaling, information visualization.

Vijay Natarajan, R. Venkatesh Babu

Hansen, C.D., and Johnson, C.R., Visualization Handbook, Academic Press, 2004.
Ware, C., Information Visualization: Perception for Design, Morgan Kaufmann, Second Edn, 2004.
Current literature

SE 295 (JAN) 3:1
Parallel Programming

Introduction: Scope of parallel computing, challenges, performance metrics, parallel architecture models, parallel programming paradigms, algorithm models. Principles of parallel algorithm design: decomposition techniques, data distribution methods, mapping techniques for load balancing. Programming using the message passing paradigm: Principles of message-passing programming, The Message Passing Interface (MPI): MPI-1, Collective communications, MPI-2, Parallel I/O; Shared memory programming: OpenMP; Parallel applications: Laplace equation, molecular dynamics. Parallel dense linear algebra: Gaussian elimination, iterative methods. Parallel sparse linear algebra: Cholesky factorization, graph partitioning, sparse iterative methods, graph coloring and others. Other topics: Parallel FFT. Parallelism in Bioinformatics and other Applications, Scheduling on parallel systems and other advanced topics.

S Vadhiyar

Pre-requisite(s): High Performance Computing and preferably Numerical Linear Algebra and Numerical Methods.

Grama, Gupta, A., Karypis, G., Kumar, V., Introduction to Parallel Computing, Addison Wesley, 2003. ISBN: 0-201-64865-2
Dongarra, J., Foster, I., Fox, G., Kennedy, K., White, A., Torczon, L., Gropp, W. (Eds), The Sourcebook of Parallel Computing, Morgan Kaufmann, 2002. ISBN: 1-558-60871-0.
Dongarra, J., Duff, I., Sorensen, D.C., Van der Vorst, H.A., Numerical Linear algebra for High Performance Computers, 1998. ISBN –0-89871-428-1.

SE 397 (JAN) 3:1
Topics in Embedded Computing

Introduction to embedded processing, dataflow architectures, architecture of embedded SoC platforms, dataflow process networks, compiling techniques/optimizations for stream processing, architecture of runtime reconfigurable SoC platforms, simulation, design space exploration and synthesis of applications

on runtime reconfigurable SoC platforms, additional topics including but not limited to computation models for coarse grain reconfigurable architectures (CGRA), readings and case study of REDEFINE architecture, compiler back-ends for CGRAs.

S K Nandy

Pre-requisites: Basic knowledge of digital electronics, computer organization and design, computer architecture, data structures and algorithms, and consent of instructor.

Current literature.
IEEE transactions on VLSI systems.
IEEE transactions on Multimedia Systems.
ACM Transactions on embedded computing systems.
Technical reports and design notes from micro-electronics industries and other academic institutions.

SE 299 (AUG) 0:24
Dissertation Project

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

Faculty

SE 301 (AUG) 2:0
Bioinformatics

Biological Databases: Organisation, searching and retrieval of information, accessing global bioinformatics resources using internet links. Introduction to Unix operating system and network communication. Nucleic acids sequence assembly, restriction mapping, finding simple sites and transcriptional signals, coding region identification, RNA secondary structure prediction. Similarity and Homology, dotmatrix methods, dynamic programming methods, scoring systems, multiple sequence alignments, evolutionary relationships, genome analysis. Protein physical properties, structural properties – secondary structure prediction, hydrophobicity patterns, detection of motifs, structural database (PDB). Genome databases, Cambridge structure database, data mining tools and techniques, Structural Bioinformatics, Topics from the current literature will be discussed.
Hands on experience will be provided.

S Ramakumar and K Sekar

Gribkov, M., and Devereux, J. (Eds), Sequence Analysis Primer, Stockton Press, 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.

SE 303 (AUG) 2:0 Chemoinformatics

Exploring current chemoinformatics resources for synthetic polymers, pigments, pesticides, herbicides, diagnostic markers, biodegradable materials, biomimetics. Primary, secondary and tertiary sources of chemical information. Database search methods: chemical indexing, proximity searching, 2D and 3D structure and substructure searching. Introduction to quantum methods, combinatorial chemistry (library design, synthesis and deconvolution), spectroscopic methods and analytical techniques. Analysis and use of chemical reaction information, chemical property information, spectroscopic information, analytical chemistry information, chemical safety information. Representing intermolecular forces: ab initio potentials, statistical potentials, forcefields, molecular mechanics. Monte Carlo methods, simulated

annealing, molecular dynamics. High throughput synthesis of molecules and automated analysis of NMR spectra. Predicting reactivity of biologically important molecules, combining screening and structure – 'SAR by NMR'. Computer storage of chemical information, data formats, OLE, XML, web design and delivery.

Debnath Pal

Current Scientific Literature and Web lectures: http://serc.iisc.ernet.in/~dpal/lec tures.html.
Maizell, R.E., How to find Chemical Information: A guide for Practicing Chemists, Educators, and students, John Wiley and Sons, 1998. ISBN 0-471-12579-2.
Gasteiger, J., and Engel, T., Chemoinformatics. A Textbook, Wiley-VCH, 2003. ISBN: 3-527-30681-1

SE 305 (AUG) 3:1
Topics in Web-scale Knowledge Harvesting

Entity extraction, entity normalization, entity categorization, relation extraction, distant supervision, curriculum learning, knowledge base (KB) inference, open information extraction (OpenIE), temporal inference,ontology evolution, bootstrapped learning, learning from limited supervision in KBs, scalable learning and inference over large datasets for KB construction, recent KB construction systems, multilingual knowledge acquisition, knowledge acquisition from multiple modalities, representation learning for knowledge harvesting.

P P Talukdar

Pre-requisites: Basic knowledge of machine learning and/or natural languageprocessing will be helpful although not mandatory.References: Current Literature.

SE 360 (JAN) 3:0
Topics in Medical Imaging

Three-dimensional Medical Image Processing, Medical Image reconstruction using high performance computing, General Purpose Graphics Processing Units (GP-GPU) computing for Medical Image processing, reconstruction, and Analysis, Computer Aided Detection (CAD) systems – Algorithms, Analysis, Medical Image Registration: rigid and non-rigid registration, Volume based image analysis, Medical Image Enhancement: Deblurring techniques, Four-dimensional Medical Imaging, Molecular Imaging, Diffuse Optical Tomography, and Medical Image Informatics.

P K Yalavarthy

Pre-requisites: SE 260 or E9 241 or consent from the Instructor.

Current Literature

BE 201 (AUG) 3:0
Fundamental of Biomaterials and Living Matter

Basic concepts in Biomaterials Science; Bonding in materials, Structure-Property correlation; Structure of Materials at various length scales, Importance of material properties in the context of Biocompatibility, Concept of Stress and Strain, Fundamentals of Elastic, Plastic and Viscoelastic deformation, Elements of fracture of materials and concept of fracture toughness, Structure and mechanical behavior of cells, proteins, tissues, Fracture of natural bone (cortical/cancellous), Functional properties (piezoelectric, dielectric properties) of natural bone; Manufacturing and properties of biocompatible metals (Ti-alloy, Co-Cr-Mo alloys), ceramics (Hydroxyapatite, bioglass), polymers (HDPE, PMMA etc.) and composites.

Bikramjit Basu

William. D. Callister, Jr. and David G. Rethwisch: Fundamentals of Materials Science: An Integrated approach: 4th Edition; John Wiley & Sons, 2011
Basu, D. Katti and Ashok Kumar; Advanced Biomaterials: Fundamentals, Processing and Applications; John Wiley & Sons, Inc., USA, 2009.
Biomaterials Science: An introduction to Materials in Medicine, Edited by Ratnes, Hoffman, Schoet and Lemons, Second Edition: Elsevier Academic Press, 2004.
Bikramjit Basu and Kantesh Balani; Advanced Structural Ceramics; John Wiley & Sons, Inc., USA and American Ceramic Society, 2011.
Fredrick H. Silver and David L. Christiansen, Biomaterials Science and Biocompatibility, Springer, Piscataway, New Jersey, first edition, 1999.
Janathan Black, Biological Performance of Materials: Fundamentals of Biocompatibility, Marcel Dekker, Inc., New York and Basel, 1999.

BE 202 (JAN) 3:0
Thermodynamics and Transport in Biological Systems

Thermodynamics: Foundations of Classical Thermodynamics, Heat and Work, First and Second Laws, Phase Rule and Phase Equilibria, Thermodynamics of Adsorption and Binding, Chemical Reactions, Applications in Biology.
Transport: Importance of Transport Processes in Biology, Fluid Statics and Kinematics, Shell Momentum Balances, Navier-Stokes Equation, Diffusion and Fick's Law, Stokes-Einstein Relationship, Convective Transport, Reaction-Diffusion Systems, Transport across Membranes, Energy Balances

K Ganapathy Ayappa and **Narendra M Dixit**

Introduction to Chemical Engineering Thermodynamics, J. M. Smith, H. C. Van Ness and M. M. Abbott, Mc Graw-Hill, 2005.
Biological Thermodynamics, D. T. Haynie, Cambridge University Press, 2008.
Transport Phenomena, R. B. Bird, W. E. Stewart, E. N. Lightfoot, Wiley India, 2006
Transport Processes in Biological Systems, G. A. Truskey, F. Yuan and D. F. Katz, Pearson Prentice Hall, 2010

BE 203 (AUG)
Bioengineering Practicum 1

Bioengineering laboratory experience to enable the student do practical work in a particular field by working in the laboratories of the advisers. The student is expected to learn the experimental techniques

and practical methods pertaining to the research topic undertaken. The evaluation will be based on oral presentation to the faculty.

G. K. Ananthasuresh and **Sandhya Visweswariah**

BE 204 (JAN) 0:1
Bioengineering Practicum 2

Bioengineering laboratory experience to enable the student do practical work in a particular field by working in the laboratories of the advisers. The student is expected to learn the experimental techniques and practical methods pertaining to the research topic undertaken. The evaluation will be based on oral presentation to the faculty.

G. K. Ananthasuresh and **Sandhya Visweswariah**

BE 205 (JAN) 3:0
Introduction to Biomechanics of Solids

Intended to be a broad introduction to multiple aspects of biomechanics of solids, the course comprises five modules, viz., statics and dynamics of rigid bodies; elastic mechanics; mechanics of biological materials; statistical mechanics and rubber elasticity; and cell mechanobiology. Topics covered include: force-balance, Lagrange's equations of motion, Euler's equations for rigid-body dynamics with applications to human body; stiffness, inertia, and damping pertaining to bones, muscles, tissues, cells, and biological molecules; state of stress and strain, energy methods, basic concepts of elasticity and viscoelasticity; applications of statistical mechanics to cells and motor proteins, Langevin equations; and introduction to mechanotransduction.

G. K. Ananthasuresh and **Namrata Gundiah**

S. A. Berger, W. Goldsmith, and E. R. Lewis (Ed.), *Introduction to Bioengineering, Chapter 1: Biomechanics of Solids*, Oxford University Press, Oxford, 1996.
J. D. Humphrey and S. L. Delange, *An Introduction to Biomechanics: solids and Fluids, Analysis and Design*, Springer, Berlin, 2004.
D. Boal, *Mechanics of the Cell*, Cambridge University Press, Cambridge, 2001.
P. Nelson, *Biological Physics*, W. H. Freeman & Company, 2007.
J. Howard, *Mechanics of Motor Proteins and the Cytoskeleton*, Sinauer Associates, Inc., Sunderland, MA, USA, 2001.

BE 206 (AUG) 3:0
Biology and Physiology for Engineers

Basic concepts in biology: biomolecules, protein structure and function; DNA, RNA, and replication; cell biology; classification of tissues, anatomy, histology and physiology of organ systems.

Sandhya Visweswariah and **Aditya Murthy**

B. Alberts, A. Johnson, J. Lewis, M. Raff, K. Roberts, and P. Walter, Molecular Biology of the Cell, Garland Science, New York, 2007.
J. Kuriyan, B. Konforti, and D. Wemmer, The Molecules of Life: Physical and Chemical Principles, Garland Science, New York, 2012.
M. H. Ross and W. Pawlina, Histology: A text and Atlas, Lippincott Williams and Wilkins, New York, 2011.
J. E. Hall, Guyton and Hall Textbook of Medical Physiology, Saunders Elsevier, Philadelphia, 2011.

Nanoscience and Nanoengineering

M Tech Degree Programme
Centre for Nano science and Engineering
Duration: 2 years

Departmental Core 28 credits

Course	Credits	Title
NE 215	3:0	Applied Solid State Physics
NE 241	3:0	Materials Synthesis: Quantum Dots to Bulk Crystals
NE 205	3:0	Semiconductor Devices and IC Technology
NE 213/E7 213	3:0	Introduction to Photonics
NE 211	3:0	Micro/Nano Mechanics
NE 202	1:1	Micro and Nano Fabrication
NE 201	2:1	Micro and Nano Characterization
NE 221	2:1	Advanced MEMS Packaging
NE 222	3:0	Micromachining for MEMS Technology
NE 100	1:0	Technical Writing and Presentation
NE 101	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 9 credits to make up the minimum of 64 credits required to complete the M Tech Programme at CeNSE. Electives from within/outside the department can be taken with the approval of the DCC/Faculty advisor.

NE 100 (Aug) 1:0
Technical Writing and Presentation

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

S. A. Shivashankar

Lecture notes

NE 101 (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/ Other faculty
Lecture notes

NE 201 (Jan, 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 Naik / Manoj Varma and other faculty in the Centre

Lecture notes and hands-on training manuals

NE 202 (Jan, Aug) 1:1
Micro AND Nano Fabrication

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

Navakanta Bhat / K N Bhat / Cleanroom staff

Handouts on detailed process flows and device characterization schedule

NE 205 (Aug) 3:0
Semiconductor Devices and Integrated Circuit Technology

This is a foundation level course in the area of electronic device technology. Band structure and carrier statistics, Intrinsic and extrinsic semiconductor, Carrier transport, p-n junction, Metal-semiconductor junction, Bipolar Junction Transistor, Heterojunction, MOS capacitor, Capacitance-Voltage characteristics, MOSFET, JEFET, Current-Voltage characteristics, Light Emitting Diode, Photodiode, Photovoltaics, Charge Coupled Device Integrated circuit processing, Oxidation, Ion implantation, Annealing, Diffusion, Wet etching and dry plasma etching, Physical vapour deposition, Chemical vapour deposition, Atomic layer deposition, Photolithography, Electron beam lithography, Chemical mechanical polishing, Electroplating, CMOS process integration, Moore's law, CMOS technology scaling, Short channel effects, Introduction to Technology CAD, Device and Process simulation and modeling.

Navakanta Bhat

Streetman and Banerjee ,Solid State Electronic Devices, Prentice-Hall
Plummer, Deal, and Griffin, Silicon VLSI Technology : Fundamentals, Practice and Modeling, Prentice-Hall

NE 211 / (Aug) 3:0
ME 237
Micro/Nano Mechanics

This is a foundation level course in mechanics which will prepare students to pursue advanced studies related to mechanical phenomena at the micro and nano scales. Basics of continuum theory, continuum hypothesis, elasticity, thermoelasticity, fluid mechanics, heat conduction, electromagnetism, coupled thermal-elastic and electrostatic-elastic systems, MEMS and NEMS structures -- beams, plates, and membranes, scaling of mechanical properties and continuum limits, numerical methods for mechanical modelling, mechanics beyond continuum theory.

Rudra Pratap / Akshay Naik

John A. Palesko and David H. Bernstein, Modeling MEMS and NEMS, Chapman and Hall/CRC

NE 213/E7 213 (Aug) 3:0
Introduction to Photonics

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

Manoj Varma / Ambarish Ghosh

Bahaa Saleh and Malvin Teich, Fundamentals of Photonics, Wiley & Sons (1991)
Hecht E, Optics. Addison Wesley, 2001

NE 215 (Aug) 3:0
Applied Solid State Physics

This course is intended to build a basic understanding of solid state science, on which much of modern device
technology is built, and therefore includes elementary quantum mechanics. Review of Quantum Mechanics and solid state physics, Solution of Schrodinger equation for band structure, crystal potentials leading to crystal structure, reciprocal lattice, structure-property correlation, Crystal structures and defects, X-ray diffraction, lattice dynamics, Quantum mechanics and statistical mechanics, thermal properties, electrons in metals, semiconductors and insulators, magnetic properties, dielectric properties, confinement effects

Akshay Naik and S A Shivashankar

Stephen Elliott, Physics and Chemistry of Solids John Wiley, 1998
S. M Lindsay, Introduction to Nanoscience, Oxford (2010)

NE 221 (Jan) 2:1
Advanced MEMS Packaging

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

Prosenjit Sen / M M Nayak

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

NE 222 (Jan) 3:0
Micromachining for MEMS Technology

This course discusses different aspects of MEMS technology such as fabrication techniques and process integration. Micromachining - concepts, benefits and materials, Lithography, Bulk Micromachining, Surface micromachining and related technologies, Micromachining for high aspect ratio microstructures (DRIE), Mechanical issues for MEMS, Glass and polymer micromachining, Wafer bonding technologies, Unconventional micromachining, Specific fabrication techniques / case studies for Pressure Sensors, Microphone, Accelerometers, Comb drives for electrostatic actuation and sensing, RF MEMS, Microfluidic Devices, Integration of micro machined mechanical devices with microelectronics circuits-merits and complexities.

Shankar Kumar Selvaraja / K.N. Bhat

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)
Marc J. Madou, "Fundamentals of Microfabrication and Nanotechnology - Volume II" CRC Press (2012)
Chang Liu, “Foundations of MEMS” Pearson Education International (2006)

NE 231 (Aug) 3:0
Microfluidics

This is a foundation course discussing various phenomena related to fluids and fluid-interfaces at micro-nano scale. This is a pre-requisite for advanced courses and research work related to micro-nano fluidics.Transport in fluids, equations of change, flow at micro-scale, hydraulic circuit analysis, passive scalar transport, potential fluid flow, stokes flow Electrostatics and electrodynamics, 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

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

NE 241(Jan) 3:0
Material Synthesis: Quantum Dots To Bulk Crystals

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

Srinivasan Raghavan

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 327/E3 327 (Jan) 3:0
Nanoelectronics Device Technology

The course is intended to review basic semiconductor device physics and provide a broad survey of modern device technology, in addition to an introduction to nanomaterials and their special features. Overview of Nanoelectronics devices and materials requirement, Review of basic device physics, MOS capacitor as a building block of FET, High-k dielectrics, CMOS scaling, Non idealities in MOS structure, metal gate electrodes and work function engineering, Nano MOSFET performance metrics, non-classical transistor structure; Transport in Nano MOSFET, ballistic transport, Silicon On Insulator (SOI), Multigate FET, metal-semiconductor source/drain junctions, Germanium Nano MOSFETs, Effect of strain and quantization on transistor performance, Compound semiconductor MESFETs and MOSFETs, Heterostructure MOSFETs, Electrical characterization: HFCV and LFCV, I-V and reliability measurements, Parameter extraction; Introduction to Nanomaterials (with elements of quantum mechanics).

Navakanta Bhat / K. N. Bhat/ S A Shivashankar

Taur and Ning, Fundamentals of Modern VLSI Devices, Cambridge University Press
Streetman and Banerjee, Solid State Electronic Devices, Prentice Hall
Achutan and Bhat, Fundamentals of Electronic Devices, McGraw Hill
E.H. Nicollian and J.R.Brews, MOS (Metal Oxide Semiconductor) Physics and Technology, Wiley Publishers.
International Technology Roadmap for Semiconductors (ITRS)

NE 332 (Jan) 3:0
Physics and Mathematics of Molecular Sensing

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

Manoj Varma

Lecture notes and selected publications from recent literature
Pre-requisites:
Familiarity with solution of ODEs and PDEs, knowledge of Matlab, Mathematica or an equivalent programming language, elementary probability theory

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ENERGY RESEARCH

ER : 201 (AUG) 3:0
Renewable Energy Technologies

Energy is a cretical component in the daily life of manking. 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 signigicantly affected the nergy usage patterns. Hence, renewable energy cources 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.

S Srinivasa Murthy, Pradip Dutta, Praveen Ramamurthy

Handbook of Energy Effciency and Renewable Enery, (Ed). F. Kreith and D.Y. Goswamy, CRC Press (2007)
Robert Foster, Majid Ghassemi, Alma Cota, Renewable Energy and the Environment CRC Press (2010)
Mukund R. Patel, Wind and Solar Power Systems, Taylor and Francis (2006)