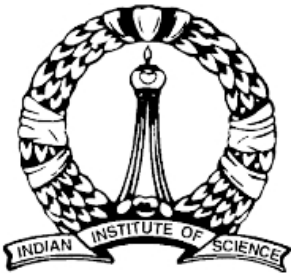
Scheme of Instruction 2015-16



Indian Institute of Science
Bangalore - 560 012

Contents

SCHEME OF INSTRUCTION
2015-16

Preface

The “Scheme of Instruction and Student Information Handbook” contains of the courses and rules and regulations related to student 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 2015
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 **12 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 research interests in the Centre for Neuroscience spans from molecules to behavior. The courses offered would enable the students to gain fundamental knowledge in molecular and cellular neuroscience, systems and cognitive neuroscience. In addition, students will be expected to actively participate in seminars, journal clubs and lab rotations.

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

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

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
DB 207 0:5	Laboratory
BC 203 3:0	General Biochemistry
MB 201 2:0	Biophysical Chemistry
MC 203 3:0	Microbiology
RD 201 2:0/ DB 204	Genetics

Projects: 16 Credits

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

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

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

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.

DB201 (AUG) 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

DB202 (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 M

- 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.

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.

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.

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

DB212 (JAN) 0:6

Project I

Faculty

DB225 (JAN) 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

DB327 (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 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, inflammation, antibody structure and function, the complement system, antigen - antibody interaction, cells and organs of the immune system, B cell activation, immunoglobulin genes, molecular basis of antibody diversity, T cell receptors, T cell activation, major histocompatibility complex, antigen processing and presentation, lymphokines, transcription factors, hypersensitivity, autoimmunity, immunological techniques. Immunological disorders and therapy

D Nandi, Anjali A Karande and Sandeep M Eswarappa

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 302 (AUG) 3:0

Current Trends in Drug Discovery

Introduction to the process of Drug discovery, Principles of drug action, Biochemical pharmacology, drug absorption, distribution, metabolism and elimination, bioavailability. Drug receptors and their interactions, dose-response relationships, pharmacokinetics & pharmacodynamics. Use of genomics and proteomics for understanding diseases at the molecular level. Brief introduction to Systems biology, Strategies for target discovery, high throughput screening using genomics, proteomics and bioinformatics for target and lead 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.

BC201 (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'Sil

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.

BC202 (AUG) 2:0

Proteins: Structure and Function

BC202(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.

BC203 (AUG) 3:0

General Biochemistry

BC203(AUG)3:0

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

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 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).

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 C. Raghavan and Arun Kumar

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

BC 209 (JAN) 2:0

Dessertation Project (Only for BC Students)

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

BC 210 (JAN) 2:0

Molecular Basis of Ageing and Regeneration

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

Purusharth I Rajyaguru & N.Ravi Sundaresan

Principles of Regenerative Biology by Bruce Carlson.
Regeneration -
Developmental Biology by Scott F Gilbert (6th Edition). Handbook of the Biology of Ageing, Seventh Edition, by Edward J Masoro (Editor), Steven N. Austad (Editor) 2010. Molecular Biology of Aging (Cold Spring Harbor Monograph Series), by Leonard Guarente, 2007. Biology of Aging : Observations and Principles by Robert Arking, 2006. Aging and age- related diseases : the basics by Karasek, M 2006. Molecular Biology of the Cell by Alberts B et al., 2008.

Ecological Sciences

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 & Farah Ishtiaq

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 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; using optimality and evolutionary models to understand behavioural strategies such as foraging, competition, mate choice, parental care, and predator-prey interactions; theoretical, integrative, phylogenetic, and computational approaches to studying animal behaviour

Rohini Balakrishnan & Maria Thaker

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; single species dynamics (reaction diffusion equations, Fisher-Kolmogorov equation, local vs long distance dispersal); metapopulations, multi-species dynamics and pattern formation (Turing patterns, cellular automata, contact process, etc); self-organization in biological systems; swarm dynamics and intelligence (agent based models); evolutionary games in space

Vishwesha Guttal

Tilman, D. and Kareiva, P. (Eds.), Spatial Ecology — The Role of Space in Population Dynamics and Interspecific Interactions, Princeton University Press, 1998
Okubo and Levin, Diffusion and Ecological Problems: Modern perspectives, (2nd edition) Springer, 2001
Nowak, M., Evolutionary Dynamics, Belknap press, 2006

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.

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 201 (JAN) 2:1

Theoretical and Mathematical Ecology

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.

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 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 (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.

Microbiology and Cell Biology

MC 203 (AUG) 3:0

Essentials in Microbiology

Fascinating world of microbes; Principles of microscopy; Microbial taxonomy, Microbial diversity, evolution and genomics; Mechanisms of horizontal gene transfer including genome transplantation, Microbes as model systems of development, Microbes as bioreactors and sensors; bioremediation; bacterial cell structure and function; Bacterial physiology and nutrition; Bacteriophages, Plasmids and Transposons; Understanding and combating bacterial pathogenesis; Antibiotics- mechanisms of drug resistance and mode of action; Quorum sensing and biofilms; Host-pathogen interactions and mechanisms of immune surveillance; PRR and their role in pathogenesis; TH subsets and modulation by pathogens; Diagnostics and vaccine development.

K. N. Balaji, Nagaraja V Dipshika Chakravortty, an

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 Dipshika Chakravortty

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. 3rdEdn, 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 mutagenesisin 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 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 UpendraNongthomb

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 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.

MC 211 (JAN) 2:0

Molecular basis of Ageing and Regeneration

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

Dr. N. Ravi Sundaresan & Dr. Purusharth I. Rajyagu

1. Principles of Regenerative Biology by Bruce Carlson. http://www.sciencedirect.com/science/book/9780123694393
2. Regeneration – Developmental Biology by Scott F Gilbert (6th edition)
3. Hand book of the Biology of Aging, Seventh Edition, by Edward J. Masoro, Steven N. Austad, 2010
4. Molecular Biology of Aging (Cold Spring Harbor Monograph Series), by Leonard Guarente , 2007
5. Biology of Aging: Observations and Principles by Robert Arking, 2006
6. Aging and age-related diseases: the basics by Karasek, M, 2006
7. Molecular Biology of the Cell by Alberts B et al., 2008

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 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 and P Aravind

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, N.Srinivasan and A.Srivastava

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 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 208 (JAN) 3:1

Theoretical and computational neuroscience

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

Rishikesh Narayanan 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 303 (JAN) 3:0

Elements of Structural Biology

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

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

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

RD 204 (AUG) 3:0

Principles of Signal Transduction in Biological Systems

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

Deepak K Saini, Varsha Singh, Ramray Bhat

RD207 (AUG) 0:3

Methodologies in Molecular and Cell Biology (MRDG students only

Theoretical understanding and hands-on experience in techniques including preparation of competent bacterial cells, bacterial transformation, DNA and RNA isolation and quantification, PCR, agarose gel electrophoresis, preparation of buffers, molecular cloning, use of radioisotopes, protein quantification, polyacrylamide gel electrophoresis, immunoblotting, cell culture, basics of microscopy and flowcytometry. (lectures by faculties on select topics; regular maintenance of lab record book which will be submitted for evaluation at the end of the term)

Faculty

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

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

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

RD208 (JAN) 0:3

Research Practical Course

Short project in laboratory, Seminars on Current Trends in Biological Research (Seminars by the students, in addition 5-6 invited seminars)

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, S Ray, S Devarajan, A Murthy

None

NS202 (AUG) 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.

Balaji Jayaprakash, Shyamala Mani, Deepak Nair and

None

NS203 (JAN) 3:0

Optical Spectroscopy and Microscopy

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

Balaji Jayaprakash

NS301 (JAN) 2:0

Topics in Systems and Cognitive Neuroscience

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

S Ray, SP Arun, S Devarajan and A Murthy

NS201

NS302 (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.

B Jayaprakash, S Mani, D Nair and N Ramanan

NS202

Division of Chemical Sciences

Preface

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

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

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 several basic as well as specialized topics designed to provide students with a sound foundation in both theoretical and experimental aspects. There are specified requirements for completing the research training programme (RTP) for students registering under different streams at the Institute. For details concerning these requirements, students are advised to approach the department Chairman or the Departmental Curriculum Committee.

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

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

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

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

The NMR Research Centre houses several modern NMR spectrometers; courses are offered at various levels, both on basic and advanced topics. In addition, the center also organizes workshops and symposia in the area of Nuclear Magnetic Resonance. In addition, it provides research facilities in the area NMR 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 0:14 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/ 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

CD 211 (AUG) 3:0

Physical Chemistry – I Quantum Chemistry and Group Theory

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

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

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

U. Maitra and S. Chandrasekhar

Anslyn, E.V., and Dougherty, D.A., Modern Physical Organic Chemistry, University Science Books, 2006.
Smith, M. B., March J., March's Advanced Organic
Chemistry: Reactions, Mechanisms and Structure, 6th ed. Wiley, 2007.
Carey F.A., and Sundberg R.J., Advanced Organic
Chemistry, Part A. 5th ed. Plenum, 2007.
Lowry T.M. and Richardson K.S., Mechanism and
Theory in Organic Chemistry, 3rd ed, Addison-Wesley-Longman, 1998.
Current literature.

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.

S. Yashonath / U. Harbola

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 241 (AUG) 0:14

Research Project

Research project in consultation with Ph. D. Supervisor, covering August and January terms

Assigned Faculty

9In consultation with the assigned faculty)

CD 221 (JAN) 3:0

Physical Chemistry II: Statistical Mechanics

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

Govardhan Reddy

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

CD 222 (JAN) 3:0

Material Chemistry

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

A.M. Umarji / K.K. Nanda / P. Barpanda

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 / T. K. Chakraborty

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

CD 224 (JAN) 2:1

Computers in Chemistry

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

Sai G Ramesh

Any accessible book on numerical methods.

CD 225 (JAN) 0:4

Physical and Analytical Chemistry Laboratory

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

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.
Relevant literature from Chemical Education (ACS Publications) and other pedagogic Chemistry Journals

CD 301 (JAN) 3:0

Advanced NMR Spectroscopy

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

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

Sai G Ramesh

Levine, I, Molecular Spectroscopy
Struve, W. S. Fundamentals of molecular spectroscopy Bernath, P. F. Spectra of atoms and molecules (2nd Ed.)
Cotton, F. A. Chemical applications of group theory

IP211 (AUG) 3:0

Physical Chemistry -1 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

IP214 (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.

IP311 (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

IP312 (AUG) 3:0

Advanced Organometallic Chemistry

Structure and bonding in organometallic compounds – isolobal analogies, metal carbonyls, carbenes and NHC complexes, olefin and acetylene complexes, alkyls and allyl complexes, 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.

IP313 (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.

IP314 (JAN) 3:0

Ultrafast Optics and Spectroscopy in Physical Chemistry

Plane wave and phase velocity, Representation of short pulses in time and frequency domain, General construction of laser, Ultrafast Laser System: Oscillator and Amplifier, Gaussian Beam characteristics, Polarization and Birefringence in ultrafast optics, Pulse Measurements in frequency and time domains, Nonlinear Ultrafast Optics: second order, third order, higher order, Dispersion in Ultrafast Optics, Ultrafast Spectroscopy: Technique, Kinetic Model, Quantum Mechanical Model, Ultrafast Physical Chemistry: Gas, Liquid, Solids, Photochemistry and Photophysics, Transition State Dynamics.

Atanu Bhattacharya

A. Weiner, Ultrafast Optics.
A. Bhattacharya, Ultrafast Optics and Spectroscopy in Physical Chemistry, Unfinished Book Draft.
R. Trebino, Ultrafast Optics, Online Book Draft
R. Guenther, Modern Optics
G. R. Fowles, Introduction to Modern Optics.

IP322 (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

IP323 (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.

IP324 (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

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.

Karuna Kar Nanda and A.M. Umarji

MR 203 (AUG) 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

Faculty

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.

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. 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 Ili, 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) 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 Coordinator : A.M. Umarji

MR 305 (AUG) 3:0

Functional Dielectrics

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

Balaram Sahoo

MR 306 (AUG) 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 (AUG) 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 (AUG) 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.

CD 222 (JAN) 3:0

Chemistry of Materials

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

K.K. Nanda, Prabeer Barpanda and A.M. Umarji

MR 203 (JAN) 3:0

Introduction to Biometerials

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.

MR 305 (JAN) 3:0

Functional Dielectrics

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

Balaram Sahoo

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 (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,

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

Organic Chemistry

OC 203 (AUG) 3:0

Organic Chemistry-I

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

Uday Maitra and Sosale Chandrasekhar

Anslyn, E.V., and Dougherty, D.A., Modern
Physical Organic Chemistry, University Science Books, 2006.
Smith, M. B., March J., March's Advanced Organic
Chemistry: Reactions, Mechanisms and Structure, 6th ed. Wiley, 2007.
Carey F.A., and Sundberg R.J., Advanced Organic
Chemistry, Part A. 5th ed. Plenum, 2007.
Lowry T.M. and Richardson K.S., Mechanism and
Theory in Organic Chemistry, 3rd ed, Addison-Wesley-Longman, 1998.
Current literature.

Pre-requisites: Successful completion of UC201 and 205 for UG

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 301 (AUG) 3:0

Organic Synthesis II

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

Kavirayani R Prasad

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.
Nicolaou, K. C., Classics in Total synthesis I and II; Wiley-VCH, Weinheim 2003; Current literature

Pre-requisites: For students registered for regular PhD programme, including those coming to regular PhD programme through Int PhD and UG streams and recommendation by research supervisor

OC 302 (AUG) 3:0

Asymmetric Catalysis: From Fundamentals to Frontiers

Basics of asymmetric catalysis including energetics of reactions; Lewis acid & Lewis base catalysis; kinetic, dynamic kinetic and parallel kinetic resolution; desymmetrization reactions; mechanistic studies of asymmetric reactions: nonlinear effects, autocatalysis and autoinduction; bifunctional, dual and multifunctional catalyst systems; modern aspects of asymmetric catalysis: counterion-directed catalysis, cooperative, dual and merged catalysis, asymmetric photocatalysis etc.; applications of asymmetric catalysis.

Santanu Mukherjee

Walsh, P. J., Kozlowski, M. C., Fundamentals of Asymmetric Catalysis, University Science Books, California, 2008.
Carreira, E. M., Kvaerno, L., Classics in Stereoselective Synthesis, Wiley-VCH, Weinheim, 2009.
Corey, E. J., Kürti, L., Enantioselective Chemical Synthesis, Direct Book Publishing, Dallas, 2010.
Current literature.
Pre-requisites: Successful completion of OC203/CD213 and CD223 (for UG and Int PhD students).

OC303 (AUG) 3:0

Carbohydrate Chemistry

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

N. Jayaraman

Monosaccharides: Their chemistry and their roles in natural products, P. Collins and R. Ferrier, John Wiley & Sons Ltd., Chichester, 1998
2. Carbohydrates: The essential molecules of life, R. V. Stick, S. J. Williams, Elsevier, Oxford, 2001
3. Organic synthesis with carbohydrates, G.-J. Boons, K. J. Hale, Blackwell Science, Inc., Malden, 2000

Pre-requisites: Regular PhD students; Int PhD students: Completion of CD213 and CD223 courses; UG students: Completion of UC205, CD213 and CD223

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 and K.R. Prabhu

OC 234 (JAN) 3:0

Organic synthesis

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

N Jayaraman and T. K. Chakraborty

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.
Pre-requisites: Chemistry major students; UG students having completed UC205, OC203/CD213

OC 303 (JAN) 3:0

Physical Methods of Structure Elucidation

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

K R Prabhu/E.N. Prabhakaran and Faculty

Stothers, J.B. Carbon-13 NMR spectroscopy, Vol.XXIV, Academic Press, 1972
Jackmann, L and Stembel, Applications NMR Spectroscopy in Organic Chemistry,
Pergamon Press 1969
Current Literature

Pre-requisites: BS (Chemistry Major) or MS

Solid State and Structural Chemistry

CD 204 (AUG) 3:0

Chemistry of materials

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

S. Natarajan, SSCU / S. Vasudevan IPC/SSCU

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

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.

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

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

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 304 (AUG) 3:0

Solar Energy: Advanced Materials and Devices

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

Satish Patil and Anshu Pandey

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

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

Concepts and synthesis of ion and electron conducting polymers, characterization methods, co-polymers, blends and composites. Physical and chemical properties of polymers: structural correlations with glass transition, viscoelasticity; mechanisms of electronic and ionic transport. 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
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.
Review Papers

Division of Physical and Mathematical Sciences

Preface

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

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

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

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

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

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

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

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

Prof Rahul Pandit
Chairman
Division of Physical &
Mathematical Sciences

Instrumentation and Applied Physics Mathematics

IN 201 (AUG) 3:0

Analytical Instrumentation

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

S Asokan and S Umapathy

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 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 224 (AUG) 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.
G.A.F.SEBER. Linear regression analysis-John Wiley & Sons.1977.

IN 229 (AUG) 3:0

Advanced Instrumentation Electronics

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

Atanu 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 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 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 fabrication Procedures (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-chips 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

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; generalized functions, 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 212 (JAN) 3:0

Advanced Nano/Micro Systems

Fundamentals of MEMS & NEMS fabrication, Physical properties of MEMS and NEMS devices, doping, pattern generation, tools for nanoscale characterizations, CMOS based devices, Advanced sensing systems such as image sensor, touch sensors, accelerometer, gyroscope, flow sensors, actuators, transducers, thermal sensor, electrostatic, piezoelectric 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 electron 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 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 (JAN) 3:0

Plasma Processes

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

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 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, Quantitative feedback theory control of non-minimum phase systems, Bode sensitivity integrals, use of describing 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 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. Interferometry: 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

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 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 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 (JAN) 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 Differential Equations
MA 242	3:0	Partial Differential Equations.
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 I

Part A

1. Groups: definitions & basic examples;
2. Normal subgroups, quotients;
3. Three isomorphism theorems;
4. Centralizer and normalizer of a subset, centre of a group;
5. Permutations, symmetric groups and Cayley's Theorem;
6. Group actions and their applications, Sylow's theorems.

Part B

1. Rings and ideals: basic definitions, quotient rings;
2. The Chinese Remainder Theorem;
3. Maximal and prime ideals;
4. Unique factorization, unique factorization domains, principal ideal domains, Euclidean domains, polynomial rings;
5. Modules: basic definitions and examples, Hom and tensor products, the Structure Theorem for finitely generated modules over PIDs;
6. Fields: basic definitions and examples, algebraic & transcendental numbers;
7. Finite fields, characteristic, the order of a finite field.

ABHISHEK BANERJEE

RECOMMENDED TEXTS:
1. Artin, M., Algebra, Prentice-Hall of India, 1994.
2. Dummit, D.S. and Foote, R.M., Abstract Algebra, John Wiley & Sons, 2001.
3. Herstein, I.N., Topics in Algebra, John Wiley & Sons, 1995.
4. Lang, S., Algebra, 3rd edition, Springer, 2002.

MA 215 (AUG) 3:0

Introduction to Modular Forms

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

JABAN MEHER

RECOMMENDED TEXTS:
1. Serre, J. P., A Course in Arithmetic, Graduate Texts in Mathematics no. 7, Springer-Verlag, 1996.
2. Koblitz, N., Introduction to Modular Forms, Graduate Texts in Mathematics no. 97, Springer-Verlag, 1984.
3. Iwaniec, H., Topics in Classical Automorphic Forms, Graduate Studies in Mathematics 17, AMS, 1997.
4. Diamond, F. and Schurman, J., A First Course in Modular Forms, Graduate Texts in Mathematics no. 228, Springer-Verlag, 2005.

PREREQUISITES:
MA 224 (Complex Analysis) or equivalent

MA 219 (AUG) 3:0

Linear Algebra

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

HARISH SESHADRI

RECOMMENDED TEXTS:
1. Artin, M., Algebra, Prentice-Hall of India, 1994.
2. Halmos, P., Finite-dimensional Vector Spaces, Springer-Verlag (UTM), 1987.
3. Hoffman, K. and Kunze, R., Linear Algebra, 2nd Edition, Prentice-Hall of India, 1992.

MA 221 (AUG) 3:0

Analysis I: Real Analysis

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

S. THANGAVELU

RECOMMENDED TEXTS:
1. Rudin, W., Principles of Mathematical Analysis, McGraw-Hill, 1985.
2. Apostol, T.M., Mathematical Analysis, Narosa, 1987.

MA 223 (AUG) 3:0

Functional Analysis

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

T. BHATTACHARYYA

RECOMMENDED TEXTS:
1. Goffman, C. and Pedrick, G., First Course in Functional Analysis, Prentice-Hall of India, 1995.
2. Rudin, W., Functional Analysis, 2nd Edition, Tata McGraw-Hill, 2006.
3. Yosida, K., Functional Analysis, 4th Edition, Narosa, 1974.

MA 231 (AUG) 3:0

Topology

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

SIDDHARTHA GADGIL

RECOMMENDED TEXTS:
1. Armstrong, M. A., Basic Topology, Springer (India), 2004.
2. Munkres, J.R., Topology: a First Course, Prentice-Hall of India, 1983.
3. Viro, O.Ya., Ivanov, O.A., Netsvetaev, N., and Kharlamov, V.M., Elementary Topology: Problem Textbook, AMS, 2008.

MA 232 (AUG) 3:0

Introduction to Algebraic Topology

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

BASUDEB DATTA

RECOMMENDED TEXTS:
1. Armstrong, M. A., Basic Topology, Springer (India), 2004.
2. Hatcher, A., Algebraic Topology, Cambridge University Press, 2002.

MA 242 (AUG) 3:0

Partial Differential Equations

First-order partial differential equations: Method of characteristics, Cauchy problem, Hamilton-Jacobi equations (including either the Hopf-Lax formula or introduction to viscosity solutions, as per audience interest). Second-order partial differential equations: The Cauchy problem and classification of second-order equations, Holmgren's uniqueness theorem, Laplace equation, Heat equation, Wave equation, Some methods of solutions, Variable separable method. Brief introduction to the weak formulation (time permitting): Motivations, Dirichlet Functional.

MRINAL K. GHOSH

RECOMMENDED TEXTS:
1. John, F., Partial Differential Equations, Springer (International Student Edition), 1971.
2. 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.

ARVIND AYYER

RECOMMENDED TEXTS:
1. Ross, S.M., Introduction to Probability Models, Academic Press 1993.
2. Taylor, H.M. and Karlin, S., An Introduction to Stochastic Modelling, Academic Press, 1994.

MA 277 (AUG) 3:0

Nonlinear Dynamics

Conservative systems: Hamiltonians, canonical transformations, the nonlinear pendulum, perturbative methods, standard map, Lyapunov exponents, chaos, KAM theorem, Chirikov criterion. Dissipative systems: the logistic map, period-doubling, chaos, strange attractors, fractal dimensions, Smale horseshoe, coupled maps.

THIRUPATHI GUDI

RECOMMENDED TEXTS:
1. Lichtenberg, A. J. and Lieberman, M. A., Regular and Stochastic Motion, Springer-Verlag, 1983.
2. Guckenheimer, J. and Holmes, P., Nonlinear Oscillations, Dynamical Systems and Bifurcations of Vector Fields, Springer-Verlag, 1983.

MA 278 (AUG) 3:0

Introduction to Dynamical Systems Theory

The course introduces basic mathematical techniques to understand qualitatively the long-term behaviour of systems evolving in time. Most of the phenomena occurring in nature, and around us, are nonlinear in nature and often these exhibit interesting behaviour which could be unpredictable and counterintuitive. Tools and techniques of dynamical systems theory help in understanding the behaviour of systems and in gaining control over their behaviour, to a certain extent. Dynamical systems theory has wide applications in the study of complex systems, including physical & biological systems, engineering, aerodynamics, economics, etc.

Janaki Balakrishnan/G Rangarajan

Familiarity with linear algebra – matrices, and ordinary differential equations

S. Strogatz, Nonlinear Dynamics and Chaos: with Applications to Physics, Biology,

Chemistry, and Engineering, Westview, 1994
S. Wiggins, Introduction to applied nonlinear dynamics & chaos, Springer-Verlag, 2003.
K. Alligood, T. Sauer, & James A. Yorke, Chaos: An Introduction to Dynamical Systems, Springer-Verlag, 1996.
M. Tabor, Chaos and Integrability in Non-linear Dynamics, Wiley, 1989.

MA 361 (AUG) 3:0

Probability Theory

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

MANJUNATH KRISHNAPUR

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

MA 368 (AUG) 3:0

Topics in Probability and Stochastic Processes

Conditional probability. Discrete parameter martingales and applications. Brownian motion and its properties. Ergodic theory.

MANJUNATH KRISHNAPUR

RECOMMENDED TEXTS:
1. Williams, D., Probability with Martingales, Cambridge University Press, 1991.
2. Morters, P. and Peres, Y., Brownian Motion, Cambridge University Press, 2010.
3. Billingsley, P., Convergence of Probability Measures, 2nd edition, John Wiley & Sons, Inc., 1999.
4. Durrett, R., Probability: Theory and Examples, 4th edition, Cambridge University Press, 2010.
5. Walsh, J., Knowing the Odds: An Introduction to Probability, AMS, 2012.

MA 213 (JAN) 3:0

Algebra II

Part A
1. Introduction to categories and functors, direct and inverse limits;
2. Field of fractions of an integral domain, localization of rings;
3. i-adic completion of rings;
4. Tensor products, short exact sequences of modules;
5. Noetherian rings and modules, Hilbert Basis Theorem, Jordan-Holder Theorem;
6. Artinian rings, Artinian implies Noetherian, Krull-Schmidt Theorem.

Part B
1. Splitting fields, normal and separable extensions;
2. Application to finite fields;
3. The Fundamental Theorem of Galois Theory;
4. The Primitive Element Theorem.

MOUSUMI MANDAL

RECOMMENDED TEXTS:
1. Artin, M., Algebra, Prentice-Hall of India, 1994.
2. Dummit, D.S. and Foote, R.M., Abstract Algebra, John Wiley & Sons, 2001.
3. Lang, S., Algebra, 3rd edition, Springer, 2002.
4. Atiyah, M. and MacDonald, R., Introduction to Commutative Algebra, Addison-Wesley (or any reprint).

MA 222 (JAN) 3:0

Analysis II: Measure and Integration

Sigma-algebras, outer measures and measures. Construction of Lebesgue measure. Measurable functions. Lebesgue integration and integration with abstract measures. Monotone convergence theorem, Fatou's lemma and the dominated convergence theorem. Comparison of Riemann integration and Lebesgue integration. Product sigma-algebras, product measures, Fubini's theorem. Signed measures and the Radon-Nikodym theorem. L^p spaces, characterization of continuous linear functionals on L^p spaces. Complex measures, the Riesz representation theorem.

A.K. NANDAKUARAN

RECOMMENDED TEXTS:
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, complex-analytic functions, and the Cauchy-Riemann condition. Cauchy's integral integral formula, power series. Liouville's theorem and applications. The maximum-modulus principle. Morera's theorem, Schwartz reflection principle. Isolated singularities and the residue theorem. Contour integration. Möbius transformations, conformal mappings. Normal families and Montel's theorem. The Riemann Mapping Theorem. The Schwarz Lemma: proof, applications, automorphisms of the unit disc. Basics of analytic continuation (time permitting).

GAUTAM BHARALI

RECOMMENDED TEXTS:
1. Ahlfors, L.V., Complex Analysis, McGraw-Hill, 1979.
2. Conway, J.B., Functions of a Complex Variable, Springer-Verlag, 1978.

MA 229 (JAN) 3:0

Calculus on Manifolds

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

GADADHAR MISRA

RECOMMENDED TEXTS:
1. Spivak, M., Calculus on Manifolds, W.A. Benjamin Co., 1965.
2. Hirsch, M.W., Differential Topology, Springer-Verlag, 1997.

MA 241 (JAN) 3:0

Ordinary Differential Equations

Basic concepts: Introduction and examples through physical models, first and second order equations, general and particular solutions, linear and nonlinear systems, linear independence, solution techniques.
Existence and uniqueness theorems: Peano and Picard 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 stability: Lyapunov's method, non-linear perturbation of linear systems, periodic solutions and the Poincare-Bendixson theorem.

THIRUPATHI GUDI

1. Hartman, P., Ordinary Differential Equations, Birkhaeuser, 1982.
2. Coddington, E. A. and Levinson, N., Theory of Ordinary Differential Equations, Tata McGraw-Hill, 1972.
3. Perko, L., Differential Equations and Dynamical Systems, Springer-Verlag, 1991.

MA 313 (JAN) 3:0

Algebraic Number Theory

Algebraic preliminaries:
Algebraic field extensions: Normal, separable and Galois extensions. Euclidean rings, principal ideal domains and factorial rings. Quadratic number fields. Cyclotomic number fields.
Algebraic integers: Integral extensions: Algebraic number fields and algebraic integers. Norms and traces. Resultants and discriminants. Integral bases.
Class numbers: Dedekind rings. Lattices and Minkowski theory. Finiteness of class number. Dirichlet's unit theorem.
Ramification Theory: Discriminants.

Applications to cryptography.

DILIP P. PATIL

RECOMMENDED TEXTS:
1. Artin, E., Galois Theory, University of Notre Dame Press, 1944.
2. Borevich, Z. and Shafarevich, I., Number Theory, Academic Press, New York, 1966.
3. Cassels, J.W. and Frohlich, A., Algebraic Number Theory, Academic Press, New York, 1993.
4. Hasse, H., Zahlentheorie, Akademie Verlag, Berlin, 1949.
5. Hecke, E., Vorlesungen uber die Theorie der algebraischen Zalhen, Chelsea, New York, 1948.
6. Samuel, P., Algebraic Theory of Numbers, Hermann, 1970.

PREREQUISITES:
1. Linear algebra (MA 219 or equivalent)
2. Basic algebra: Groups, rings, modules (MA 212 or equivalent), and algebraic field extensions

MA 314 (JAN) 3:0

Introduction to Algebraic Geometry

Affine algebraic sets, Hilbert basis theorem, Hilbert Nullstellensatz, function field, plane curves, Bezout's theorem, product, normality, morphisms, Noether normalisation. Graded rings, projective varieties, rational functions, tangent spaces, non-singularity, blowing up points, divisors, Riemann-Roch for curves. Schemes and examples.

UMESH DUBEY

RECOMMENDED TEXTS:
1. Shafarevich, I.R., Basic Algebraic Geometry 1, 2nd edition, Springer-Verlag, 1994.
2. Smith, K., Kahanpää, L., Kekäläinen, P., Traves, W., An Invitation to Algebraic Geometry,Springer-Verlag, 2000.
3. Reid, M., Undergraduate Algebraic Geometry, London Mathematical Society Student Texts 12, Cambridge University Press, 1988.
4. Fulton, W., Algebraic Curves (http://www.math.lsa.umich.edu/~wfulton/CurveBook.pdf)
5. Holme, A., A Royal Road to Algebraic Geometry, Springer, 2012.

MA 315 (JAN) 3:0

Lie Algebras and Their Representations

To be announced: Please visit the webpage
http://www.math.iisc.ernet.in/newcourse.htm
and follow the link therein.

E.K. NARAYANAN

MA 317 (JAN) 3:0

Introduction to Analytic Number Theory

Review of arithmetical functions, averages of arithmetical functions, elementary results on the distribution of prime numbers, Dirichlet characters, Dirichlet's theorem on primes in arithmetic functions, Dirichlet series and Euler products, the Riemann zeta function and related objects, the prime number theorem.
(Time permitting: advanced topics like sieves, bounds on exponential sums, zeros of zeta functions, the circle method.)

SOUMYA DAS

RECOMMENDED TEXTS:
1. Apostol, T.M., Introduction to Analytic Number Theory, Springer-Verlag, 1976.
2. Davenport, H., Multiplicative Number Theory, 3rd edition, Springer, 2000.

PREREQUISITES:
1. MA 224 (Complex Analysis) or equivalent
2. An introductory course in Number Theory, or consent of instructor

MA 319 (JAN) 3:0

Algebraic Combinatorics

The algebra of symmetric functions, Schur functions, RSK algorithm, Murnaghan-Nakayama Rule, Hillman-Grassl correspondence, Knuth equivalence, jeu de taquin, promotion and evacuation, Littlewood-Richardson rules.
No prior knowledge of combinatorics is expected, but a familiarity with linear algebra and finite groups will be assumed.

ARVIND AYYER

RECOMMENDED TEXTS/NOTES:
1. Stanley, R., Enumerative Combinatorics, volume 2, Cambridge University Press, 2001.
2. Sagan, B., The Symmetric Group: Representations, Combinatorial Algorithms, and Symmetric Functions, Graduate Texts in Mathematics vol. 203, Springer-Verlag, 2001.
3. Prasad, A., Representation Theory: A Combinatorial Viewpoint, Cambridge Studies in Advanced Mathematics vol. 147, 2014.
4. Stanley, R., Lecture notes on "Topics in Algebraic Combinatorics".

MA 320 (JAN) 3:0

Representation Theory of Compact Lie Groups

Lie groups, Lie algebras, matrix groups, representations, Schur's orthogonality relations, Peter-Weyl theorem, structure of compact semisimple Lie groups, maximal tori, roots and root-spaces, classification of fundamental systems, Weyl group, highest-weight theorem, Weyl integration formula, Weyl's character formula.

S. THANGAVELU

RECOMMENDED TEXTS:
1. Knapp, A.W., Representation Theory of Semismiple Lie Groups: An Overview Based on Examples, Princeton University Press, 2002.
2. Hall, B.C., Lie Groups, Lie Algebras and Representations, Springer-Verlag, 2003.
3. Simon, B., Representations of Finite and Compact Groups, AMS, 1996.
4. Varadarajan, V.S., Lie Groups, Lie Algebras and their Representations, Sringer-Verlag, 1984.

MA 364 (JAN) 3:0

Linear and Nonlinear Time Series Analysis

Linear time series analysis: Modelling time series using stochastic processes, stationarity, autocovariance, autocorrelation. Multivariate analysis: AR, MA, ARMA, AIC criterion for order selection. Spectral analysis: deterministic processes, the concentration problem, stochastic spectral analysis, nonparametric spectral estimation (periodogram, tapering, windowing), multitaper spectral estimation, parametric spectral estimation (Yule-Walker equations, Levinson-Durbin recursion). Multivariate analysis: coherence, causality relations. Bootstrap techniques for estimation of parameters. Nonlinear time series analysis: Lyapunov exponents, correlation dimension, embedding methods, surrogate data analysis.

G. RANGARAJAN

RECOMMENDED TEXTS:
1. Box, G.E.P. and Jenkins, G.M., Time Series Analysis, Holden-Day, 1976.

2. Efron, B., The Jackknife, the Bootstrap and Other Resampling Plans, SIAM, 1982.
3. Jenkins, G.M. and Watts, D.G., Spectral Analysis and its Applications, Holden-Day, 1986.
4. Parker, T.S. and Chua, L.O., Practical Numerical Algorithms for Chaotic Systems, Springer-Verlag, 1989.

MA 201 (JAN) 7:0

Project

7-credit project; required for completion of the course requirement of the Integrated Ph.D. programme.

MUST BE TAKEN in the 4th semester of the Integrated Ph.D. programme, and completed by June 30 of the Summer Term following that semester.

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 303/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); Metapopulationdynamics. (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.

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 K.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.

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 203 (AUG) 3:0

Quantum Mechanics-1

Historical foundations. Wave function for a single particle. Hamiltonian. Schrodinger equation. Probability current. Wave packets. One-dimensional problems: step, barrier and delta-function potentials. Tunnelling, scattering and bound states. Harmonic oscillator, operator approach. Matrix formulation of quantum mechanics. Hermitian and unitary operators. Orthonormal basis. Momentum representation. Uncertainty relations. Postulates of quantum mechanics. Heisenberg representation. Ehrenfest's theorem. Threedimensional problems. Rotations, angular momentum operators, commutation relations. Spherical harmonics. Hydrogen atom, its spectrum and wave functions. Symmetries and degeneracies. Spin angular momentum. Spin-1/2 and two-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, JohnWiley, 1977.
Landau, L.D., and Lifshitz E.M., Quantum Mechanics, Pergamon, NY, 1974.
R. Shankar, Principles of Quantum Mechanics, Springer, 2010

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.

Dr.Tanmoy Das

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 209 (AUG) 2:1

Electronics II

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

K.Rajan
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
K.S.R.Ko

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/ Ambarish Ghosh / R.Ganes

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
Tarun Deep 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 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 Chandra Mallik
Jaydeep K.Basu

PH 320 (AUG) 3:0

Consensed 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.

Vijay B.Shenoy

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 325 (AUG) 3:0

Advanced Statistical Physics

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

Rahul Pandit

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 351 (AUG) 2:0

Crystals Growth Thin Films

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
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 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 204 (JAN) 3:0

Quantim 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 nonrelativistic 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 206 (JAN) 3:0

Electromagnetic Thoery

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

Electronics I

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

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 Jan

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 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.

K.S.R.Koteswara Rao
Suja Elizabeth

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

PH 250A (JAN) 0:6

Project I

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

Faculty

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

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 nonlinear 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 352 (JAN) 3:0

Semiconductor Physics

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

Prof.V.Venkataraman

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

Ajay K. Sood
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 temperature

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.

Ambarish Ghosh

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

PH 250B (JAN) 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

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.

.Arun Mangalam(IIA)

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.

Prateek Sharma

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) 3:0

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.

Shankarasubramanian(ISRO)
A.Deshpande (RRI)

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 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)
S.K.Sethi(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.

S.P. Rajaguru (IIA)
Anuj Nandi (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 & 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.

Subinoy Das (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) 2:0

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.

Prajwal Shastri IIA)
R.T.Gangadhara (IIA)

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

Sudhir K. Vempati

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

HE 391 (AUG) 3:0

Quantum Mechanics III

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

Apoorva D. Patel

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 (Third edition),
Springer, 1990.
Peskin M.E. and Schroeder D.V., An Introduction to Quantum Field Theory,
Addison Wesley, 1995.

HE 395 (AUG) 3:0

Quantum Field Theory I

Scalar, spinor and vector fields. Canonical quantisation, propagators. Symmetries and Noether theorem. Path integrals for bosonic and fermionic fields, generating functionals. Feynman diagrams. S-matrix, LSZ reduction formula. Interacting scalar and Yukawa theories. Covariant derivatives and gauge theories. Quantum electrodynamics. Gauge invariance, massless photons, Ward identity. Elementary processes. Scattering cross-sections, optical theorem, decay rates. Loop diagrams, power counting, divergences. Renormalization, fixed point classification. One loop calculations in QED. Callan-Symanzik equations, beta functions. Effective field theory.

Chethan Krishnan

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

Cambridge University Press, 1996.
Ramond P., Field Theory: A Modern Primer (Second edition),
Levant Books, 2007.

HE 397 (AUG) 3:0

The Standard Model of Particle Physics

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

Rohini M. Godbole

Quantum Field Theory I and II

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

HE 316 (JAN) 3:0

Advanced Mathematical Methods in Physics

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

Sachindeo Vaidya

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

HE 392 (JAN) 3:0

String Theory

Bosonic Strings: closed and open, oriented and unoriented. Light cone quantization and spectrum. Polyakov path integral. BRST symmetry. Conformal field theory. Modular invariance. Boundary states. Classical and quantum superstrings. Spin structures and GSO projection. Type II strings. D-branes and Type I strings. Torus compactification and Heterotic strings. Current algebras and lattices. Bosonization. N=1,2 superconformal field theory.

Chethan Krishnan

Quantum Field Theory I

Green M.B., Schwarz J.H. and Witten E., Superstring Theory, Vol. I and II,
Cambridge University Press, 1989.
Polchinski J., String Theory, Vol I and II,
Cambridge University Press, 2005.
Kiritsis E., String Theory in a Nutshell,
Princeton University Press, 2007.

HE 396 (JAN) 3:0

Quantum Field Theory II

Abelian gauge theories. QED processes and symmetries. Loop diagrams and 1-loop renormalization. Lamb shift and anomalous magnetic moments. Nonabelian gauge theories. Faddeev-Popov ghosts. BRST quantization. QCD beta function, asymptotic freedom. Spinor helicity formalism for gauge theories. Composite operators, operator product expansion. Anomalies. Lattice gauge theory, strong coupling expansion.
Confinement and chiral symmetry breaking.

Aninda Sinha

Quantum Field Theory I

Schwartz M.D., Quantum field theory and the standard model,
Cambridge University Press, 2014.
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 398 (JAN) 3:0

General Relativity

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

Justin R. David

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

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

All 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 (ECE 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 ECE Departments)
ME in Microelectronic Systems (ECE and ESE Departments)

Prof. Y Narahari
Chairman,
Division of Electrical Sciences

ME Programme
Computer Science and Engineering
Credit requirements : 64 credits
Duration : Two Years

LIST OF POOL `A` COURSES (E0 200 LEVEL)

Course No	Credits	Course Title
E0 220	3:1	Graph Theory
E0 221	3:1	Discrete Structures
E0 222	3:1	Automata Theory and Computability
E0 223	3:1	Automated Verification
E0 224	3:1	Computational Complexity Theory
E0 225	3:1	Design and Analysis of Algorithms
E0 228	3:1	Combinatorics
E0 229	3:1	Foundations of Data Science
E0 235	3:1	Cryptography
E0 244	3:1	Computational Geometry and Topology
E0 249	3:1	Approximation Algorithms
E0 234	3:1	Introduction to Randomized Algorithms
E0 248	3:1	Theoretical Foundations of Cryptography

LIST OF POOL `B` COURSES (E0 200 LEVEL)

Course No	Credits	Course Title
E0 227	3:1	Program Analysis and Verification
E0 239	3:1	Software Reliability Techniques
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 264	3:1	Distributed Computing Systems
E0 271	3:1	Computer Graphics
E0 272	3:1	Formal Methods in Software Engineering
E0 252	3:1	Programming Languages : Design and Implementation

LIST OF POOL `C` COURSES (E0 and E1 200 LEVEL)

Course No	Credits	Course Title
E0 219	3:1	Linear Algebra and Applications
E0 230	3:1	Computational Methods of Optimization
E0 232	3:1	Probability and Statistics
E0 238	3:1	Artificial Intelligence
E0 268	3:1	Data Mining
E0 270	3:1	Machine Learning
E1 246	3:1	Natural Language Understanding
E1 254	3:1	Game Theory
E1 277	3:1	Reinforcement Learning
E0 250	3:1	Deep Learning

M.E. PROGRAMME
COMMUNICATION and NETWORKS
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
E2 211	3:0	Digital Communication
E2 221	3:0	Communication Networks

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

POOL A

E2 201	3:0	Information Theory
E2 203	3:0	Wireless Communication
E2 204	3:0	Stochastic Processes and Queueing Theory
E2 205	3:0	Error Correcting Codes
E2 223	3:0	Communication Protocols
E2 241	3:0	Wireless Networks
E2 242	3:0	Multi-user Detection
E8 203	3:0	RF & Optical Engineering

POOL B

E1 251	3:0	Linear and Nonlinear Optimization
E1 254	3:1	Game Theory
E2 212	3:0	Matrix Theory
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
E9 221	3:0	Signal Quantization and Compression

A. Minor in Integrated Circuits and Systems (CS)

Requirements:

- Any 3 of the courses listed below under Pools X & Y
- With at least two courses from Pool X

Will qualify a student for a ***"Minor in Integrated Circuits and Systems"***

Pool X

NE 205	3:0	Semiconductor Devices and Integrated Circuit Technology
E0 284	2:1	Digital VLSI Circuits
E3 238	2:1	Analog VLSI Circuits
E7 211	3:0	Photonics Integrated Circuits

Pool Y

E3 237	3:0	Integrated Circuits for Wireless Communication
E3 239	2:1	Advanced VLSI Circuits
E8 262	3:0	CAD for High Speed Chip-Package-Systems

B. Minor in Photonics

Requirements:

- Any 3 of the courses listed below under Pools X & Y
- With at least two courses from Pool X

Will qualify a student for a ***"Minor in Photonics".***

Pool X

NE213/E7 213	3:0	Introduction to Photonics
E7 231	3:0	Fiber Optic Networks
E8 203	3:0	RF & Optical Engineering

Pool Y

IN 247	3:0	Principles of Tomographic Imaging
E3 214	3:0	Microsensor Technologies
E7 211	3:0	Photonics Integrated Circuits

C. Minor in Radio-Frequency Systems

Requirements:

- Any 3 of the courses listed below under Pools X & Y
- With at least two courses from Pool X

Will qualify a student for a Minor in ***"Minor in Radio-Frequency Systems".***

Pool X

E3 237	3:0	Integrated Circuits for Wireless Communication
E8 242	2:1	Radio Frequency Integrated Circuits and Systems

Pool Y

E8 202	2:1	Computational Electromagnetics
E8 203	3:0	RF & Optical Engineering
E8 262	3:0	CAD for High Speed Chip-Package-Sytems

D. Minor in Signal Processing

Requirements:

- Any 3 of the courses listed below under Pools X & Y
- With at least two courses from Pool X

Will qualify a student for a Minor in ***"Minor in Signal Processing".***

Pool X

E9 202	3:0	Advanced digital Signal Processing : Non-linear Filters
E9 211	3:0	Adaptive Signal Processing
E9 212	3:0	Spectrum Analysis
E9 213	3:0	Time-Frequency Analysis
E9 221	3:0	Signal Quantization and Compression

Pool Y

E1 213	3:1	Pattern Recognition and Neural Networks
E1 216	3:1	Computer Vision
E9 203	3:0	Compressed Sensing and Sparse Signal Processing
E9 231	3:0	Digital Array Signal Processing
E9 241	3:0	Digital Image processing
E9 252	3:0	Mathematical Methods and Techniques in Signal Processing
E9 261	3:1	Speech Information Processing
E9 262	3:0	Stochastic Models for Speech/Audio

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.

DEPARTMENT OF ELECTRICAL ENGINEERING
M E Programme
Signal Processing : (2015-2017)

Duration : 2 years **Total credits : 64 credits** **Core Courses** **Hard Core: 12 credits (All courses are compulsory)**		
E1 244	3:0	Detection and Estimation Theory
E1 251	3:0	Linear and Nonlinear Optimization
E2 202	3:0	Random Processes
E2 212	3:0	Matrix Theory
Soft Core : Minimum of 12 credits		
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
Project: 28 Credits		
EP 299	0:28	Dissertation Project

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

M.E. PROGRAMME
MICROELECTRONIC SYSTEMS
DURATION: 2 YEARS
Courses Credit Requirement: 64 credits

CORE COURSES :18 credits

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

Pool A : Materials, Processes and Device Technology

E3 214	3:0	Microsensor Technologies
E3 225	3:0	Submicron Device Modeling and Simulation
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

Pool B : Circuits, CAD, Systems and Applications

E0 283	3:0	CAD Algorithms for VLSI Physical Design
E0 284	2:1	Digital VLSI Circuits
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
E0 285	3:0	Computer Aided Design of VLSI Systems
E0 286	3:0	Test and Verification for SOC Designs
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
SE 273	3:1	Processor Design
E7 312	3:0	Selected Topics in Photonics

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 : 18 credits
The remaining 18 credits can be additional courses from either Pool A or Pool B or any other courses offered in the Scheme of Instructions.

DEPARTMENT OF ELECTRCIAL ENGINEERING
M E Programme
Systems Science & Automation (SSA) (2015-2017)

Duration: 2 years **Credit requirement : 64 credits** **Core Courses** **Hard Core: 13 Credits**		
E0 251	3:1	Data Structures and Algorithms
E1 222	3:0	Stochastic Models and Applications
E1 241	3:0	Dynamics of Linear Systems
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 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).		

DEPARTMENT OF ELECTRCIAL ENGINEERING
M E Programmes in
ELECTRICAL ENGINEERING
(EE) (2015-2017)

Duration: 2 years **64 credits** **Core Courses:**		
Pool A (One Course out of Two Courses)		
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	3:0	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 Tech Degree Programme
Electronics Systems Engineering
Duration : 2 years, Credit requirement : 64 credits

1. **Core courses (9 credits):** There are 3 courses (each 2:1) that are mandatory for M. Tech students.
2. **Courses from Pools A, B and C (15 credits):** Courses have been grouped into 3 pools – *Electronics* (Pool A), *Systems* (Pool B) and *Abstractions* (Pool C). Each student is expected to take a *minimum* of 6 credits from the *Electronics* pool, 6 credits from the *Systems* pool and 3 credits from the *Abstractions* pool.
3. **Electives (15 credits):** The remaining 15 credits of coursework may be completed by crediting courses listed in the Scheme of Instructions. This includes courses in Pools A, B and C.
4. **Project (25 credits):** This remains unchanged.

The courses are shown in the table below.

CORE Courses (all 2:1)

- Essential Circuits for System Design (**new: proposed syllabus attached) (proposed number: E3 230)**
- Electronic Systems Packaging **(E3 262)**
- Mathematics for Electrical Engineers **(E2 243)**

ELECTRONICS (minimum of 2 courses)	**SYSTEMS (minimum of 2 courses)**	**ABSTRACTIONS (minimum of 1 course)**
• Digital VLSI Circuits **(E0 284)** • Digital System Design with FPGAs **(E3 231)** • Analog and Data Conversion Systems **(E3 235)** • Analog VLSI Circuits **(E3 238)** • Advanced ESD Devices, Circuits and Design Methods **(E3 272)** • Power Semiconductor Devices and Physics **(E3 274)** • Design of Power Converters **(E6 202)**	• Digital Controller Design (**E1 243)** • Incremental Motion Control (**E1 247)** • TCP-IP Networking **(E2 232)** • Embedded Systems-1 **(E3 257)** • Design for Internet of Things (**E3 258)** • Industrial Design of Electronic Equipment **(E3 264)** • Electromagnetic Compatibility (**E3 266)** • Reliability of Nanoscale Circuits and Systems (**E3 271)** • Design and Control of Power Converters and Drives **(E6 212)** • Design of Photovoltaic Systems (**E6 222)**	• Selected Topics in Markov Chains and Optimization **(E1 261)** • Random Processes **(E2 202)** • Art of Compact Modelling **(E3 225)** • Communication Networks **(E2 221)** • Data Centre Networks **(E2 222)** • Signal Processing for Data Recording Channels **(E9 251)** • Mathematical Methods and Techniques in Signal Processing (**E9 252)** • Creative Engineering Design **(PD 203)**

E0 Computer Science and Automation

E0 201 (AUG) 3:0

Proofs and Measures

Logic, proof techniques, sets, functions, relations, cardinality, order. Point set topology, topological spaces and continuous functions, Connectedness, compactness, countability, separation axioms, metric topologies. Measures, integration, signed measures

PARIMAL PARAG

Proofs and fundamentals by Bloch
Topology by Munkres
Real Analysis by Folland
Probability path by Sidney Resnick

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

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

E0 222 (AUG) 3:1

Automata Theory and Computability

1. Automata and Logic, including Buchi's logical characterization of regular languages, automata-based decision procedures for logics of natural numbers with order (N,<), Presburger logic, and algebraic approach to regular languages.
2. Pushdown Systems, including Parikh's theorem, Reachability in pushdown systems, Deterministic PDA's and complementation, Visibly Pushdown Automata, and decidability results for PDA's and subclasses like Counter Automata.
3. Automata on infinite words, including closure properties, and Deterministic Buchi automata.
4. Automata on Trees, including closure properties, decision procedures, congruences and minimization.
5. Extended topics, including Schutzenberger-McNaughton-Papert Theorem, automata on partial-orders, distributed automata, and automata in description and analysis of infinite-state transition systems

Deepak D Souza

References:
Dexter Kozen: Automata and Computability. Springer 1999.
Wolfgang Thomas: Automata on infinite objects, in Handbook of Theoretical Computer Science, Volume B, Elsevier, 1990.
Deepak D'Souza and Priti Shankar (Eds): Modern Applications of Automata Theory, World Scientific, 2012.
Research papers.

E0 224 (AUG) 3:1

Computational Complexity Theory

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

Chandan Saha

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.

References:

• Sanjeev Arora and Boaz Barak, Computational Complexity: A Modern Approach, Cambridge University Press, 2009.
• Lecture notes of similar courses as and when required

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.

Arnab Bhattacharyya and C. Pandu Rangan

References:

• Jon Kleinberg and Éva Tardos, 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 / Deepak D Souza

References:

• Flemming Nielson, Hanne Riis Nielson, and Chris Hankin: Principles of Program Analysis, Springer, (Corrected 2nd printing, 452 pages,

ISBN 3-540-65410-0), 2005.
• Benjamin Pierce: Types and Programming Languages, Prentice-Hall India, 2002.
• Research papers

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

References:

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

E0 232 (AUG) 3:1

Probability and Statistics

Probability spaces and continuity of probability measures, random variables and expectation, moment inequalities, multivariate random variables, sequence of random variables and different modes of convergence, law of large numbers, Markov chains, statistical hypothesis testing, exponential models, introduction to large deviations.

Ambedkar Dukkipati

References:
• An Introduction to Probability and Statistics by Vijay K. Rohatgi, A. K. Md. Ehsanes Saleh, Wiley, 2nd edition 2000.
• An Intermediate course in Probability, by Allen Gut, Springer, 2008.

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 / Arpita Patra

References:

• Stinson. D, Cryptography: Theory and Practice, CRC Press, 2006.
• Menezes. A. et. al, Handbook of Applied Cryptography, CRC Press, 1996.

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

References:

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

E0 239 (JAN) 3:1

Software Reliability Techniques

Motivation:

Our dependence on software is increasing at a phenomenal rate. As a consequence, the concerns about reliability of software in terms of correctness and security are taking the center stage. In this course, we study the state-of-the-art techniques for analyzing and improving software reliability. Our focus will be on: (1) understanding the dominant models of concurrent programming and formal reasoning for them and (2) understanding the nature and causes of security vulnerabilities and techniques to detect them. We will study concurrency and security issues related to smartphone and web programming in addition to more traditional software issues.

Syllabus:

Programming and security basics: Android programming, JavaScript programming. Concurrency: multi-threading, synchronization, event-based dispatch. Dynamic analysis: security monitoring, happens-before reasoning, vector clocks, race detection. Static analysis: dataflow analysis, information flow analysis. Model checking: explicit-state model checking, symbolic model checking.

Aditya Kanade

Pre-requisite courses: None

• Programming Android, Zigurd Mednieks, Laird Dornin, G. Blake Meike and Masumi Nakamura, O'Reilly, 2011.
• Effective JavaScript, David Harman, Addison-Wesley, 2012.
• Even Faster Websites, Steve Souders, O'Reilly, 2009.
• Additional research papers.

E0 243 (AUG) 3:1

Computer Architecture

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

R. Govindarajan/ Matthew Jacob Thazhuthaveetil

References:

• Hennessy, J.L., and Patterson, D.A.: Computer Architecture, A quantitative Approach, Morgan Kaufmann.
• Current literature

E0 244 (JAN) 3:1

Computational Geometry and Topology

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

Sathish Govindarajan / Vijay Natarajan

Prerequisites

• E0225 : Design and Analysis of Algorithms
References:

• Computational Topology : An Introduction, Herbert Edelsbrunner and John L. Harer, American Mathematical Society, Indian Edition, 2010.
• Computational Geometry: Algorithms and Applications, Mark de Berg, Otfried Cheong, Marc van Kreveld, and Mark Overmars, Third Edition, Springer (SIE), 2011.
• Geometric Approximation Algorithms, Sariel Har-Peled, American Mathematical Society, Indian Edition, 2013.

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: Open CV 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, A press 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

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

E0 247 (AUG) 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.

Rathna G N

Pre-requisites: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 248 (AUG) 3:1

Theoretical Foundations of Cryptography

One-way functions, indistinguishability, pseudo-random generators, pseudo-random functions, trapdoor permutations, encryption, digital signatures, hash functions, commitments and some special topics (private information retrieval, zero-knowledge proofs etc.).

Bhavana Kanukurthi

Prerequisites: Mathematical maturity
References :
Oded Goldreich, Foundations of Cryptography: Volumes 1 and 2, Cambridge University Press, 2001 and 2004.

E0 250 (JAN) 3:1

Deep Learning

Motivation and objectives of the course : Most of the machine learning algorithms give very good accuracies provided one feeds the algorithms with as set of `handpicked' features that are extracted from the data. To automate this task, one has to take a recourse to `deep' models'. In recent years deep architectures have gained a lot of prominence for learning complex AI tasks. This course will cover basic deep learning techniques and how to apply these to solve challenging problems in computer vision and speech.
Syllabus : Basics: Maximum entropy and exponential family, Ising models, Boltzmann machines, Gibbs sampling, variational inference. Unsupervised feature learning: Restricted Boltzmann machines (RBM), Gaussian RBMs, Contrastive divergence, Deep Boltzmann machines, Autoencoders, Denoising, Recursive, Sparse coding. Supervised feature learning: Neural networks and back propagation algorithm, Convolutional Neural networks, Recurrent neural network, Deep belief networks.

Ambedkar Dukkipati

Prerequisites (if any) : A course in probability

Yoshua Bengio, Learning Deep Architectures for AI, Now Publishers, 2009.
Kevin Murphy, Machine Learning - A Probabilistic Perspective, MIT Press, 2012.
Li Deng and Dong Yu, Deep Learning: Methods and Applications, Now Publishers, 2014.

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 amortized 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.

Sathish Govindarajan and Minati De

References:

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

E0 252 (JAN) 3:1

Programming Languages : Design and Implementation

Features and implementation of imperative, object-oriented, concurrent, distributed, logicprogramming, 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 moderate size programming assignments and seminars.

Y.N. Srikant

Prerequisites

• 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).

References:

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

K. Gopinath / Murali Krishna Ramanathan

• Andrew S. Tanenbaum: Modern Operating Systems, Second Edition, Pearson Education, Inc., 2001.
• Uresh Vahalia: UNIX Internals: The New Frontiers, Prentice-Hall, 1996.
• J. Mauro and R. McDougall: Solaris Internals: Core Kernel Architecture, Sun Microsystems Press, 2001.
• Daniel P. Bovet and Marco Cesati: Understanding the Linux kernel, 2nd Edition O'Reilly & Associates, Inc., 2003.

E0 254 (AUG) 3:1

Network and Distributed Systems Security

Security Requirements of Distributed Systems; Security Violations, Security Goals, Security Services, Security Protocols, and Security Mechanisms; Attack on Security Protocols and Security Mechanisms; Secret Sharing Techniques and One-Way Functions; Discrete Logs, Block Encryption/Decryption Functions, Hash Functions, and MAC Functions; Algorithmic Implementation and Security Requirements of One-Way Functions; OS Security Violations and Techniques to Prevent Them; Access Control Models; Authenticated Diffie-Hellman Key Establishment Protocols; Group Key Establishment Protocols; Block Ciphers and Stream Ciphers; Block Cipher Modes of Encryption; Nonce, Timestamps and Authentication Protocols; Digital Signatures and Source Non-Repudiation Protocols; PKI and X.509 Authentication Service; Security Protocol Verification: Strand Space Theory; Kerberos; E-mail Security; Security Issues in Layered Communication Models: 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

Programming Assignments:

Apart from some common programming assignments, there would be an individual term project for each student. A generic description of the term project is as follows.

a. Identify the security requirements of a distributed system of your choice.
b. Design a secure system to meet the security requirements of the distributed system.
c. Give an implementation of the secure system designed in step (b) in a network of PCs using publicly available cryptographic functions.

William Stallings, "Cryptography and Network Security: Principles and Practices", Sixth Edition, Prentice Hall, 2014.
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.

Uday Kumar Reddy B.

References:

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

E0 259 (AUG) 3:1

Data Analytics

Data sets from astronomy, genomics, visual neuroscience, sports, speech recognition, computational linguistics and social networks will be analysed to answer speci?c scienti?c questions. Statistical tools and modeling techniques will be introduced as needed to analyse the data and eventually address the scienti?c question.

RAJESH SUNDARESAN and RAMESH HARIHARAN

Prerequisites for taking this course are Random Processes (E2-202) or Probability and Statistics (E0-232) or equivalent.
There is no text book for this course. Various handouts will be provided from di?erent sources.

E0 261 (AUG) 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 R. Haritsa

Prerequisites

- Data Structures, C or C++, Undergraduate course in DBMS

References:

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

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 (JAN) 3:1

Distributed Computing Systems

Fundamental Issues in Distributed Systems, Distributed System Models and Architectures; Classification of Failures in Distributed Systems, Basic Techniques for Handling Faults in Distributed Systems; Logical Clocks and Virtual Time; Physical Clocks and Clock Synchronization Algorithms; Security Issues in Clock Synchronization; Secure RPC and Group Communication; Secure Group Membership Protocols; 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; Distributed Consensus and Agreement Protocols; Replicated Data Management; Self-Stabilizing Systems; Design Issues in Specialized Distributed Systems.

R.C. Hansdah

Prerequisites: (Desirable) NDSS(E0 254) or equivalent course

Programming Assignments: Apart from some common programming assignments, there would be an individual term project for each student. In this term project, a student is expected to implement the core algorithm of some component of a distributed system to get idea of the issues involved in implementing a distributed system.
References:

• G. Coulouris, J. Dollimore, and T. Kindberg, "Distributed Systems: Concepts and Designs", Fifth Edition, Pearson Education Ltd., 2011.
• Randy Chow, and Theodore Johnson, "Distributed Operating Systems and Algorithms", Addison-Wesley, 1997.
• Sukumar Ghosh, “Distributed Systems: An Algorithmic Approach”, CRC Press, 2006.
• Kenneth P. Birman, “Reliable Distributed Systems: Technologies”, Web Services, and Applications, Springer New York, 2005.
• Current Literature

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/ Venkatesh babu

Pre-requisites: Basic knowledge of DSP and Programming
References:
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.

Shirish K. Shevade / M. Narasimha Murty

References:

- 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

Prerequisites

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

References:

• 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.

E0 271 (AUG) 3:1

Computer Graphics

Principles of computer graphics; graphics pipeline; graphics hardware; transformations; viewing; lighting; shading; modeling; selected topics in meshing, subdivision techniques, multi-resolution methods, visualization, ray tracing; individual projects.

Vijay Natarajan

Prerequisites

• Courses in linear algebra, data structures, algorithms, and programming
References:

• Edward S. Angel. Interactive Computer Graphics, A top-down approach with OpenGL. Addison-Wesley, 2005.
• OpenGL Architecture Review Board, Dave Shreiner, Mason Woo, Jackie Neider, and Tom Davis.
• OpenGL Programming Guide: The Official Guide to Learning OpenGL. Addison-Wesley, 2005.
• Donald Hearn and M. Pauline Baker. Computer Graphics with OpenGL. Prentice Hall, 2003.

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.

K.V. Raghavan / Deepak D Souza

References:

• Logic in Computer Science: Modelling and Reasoning about Systems, by Michael Huth and Mark Ryan.
• Software Abstractions: Logic, Language, and Analysis, by Daniel Jackson.
• Model Checking, by Edmund M. Clarke, Orna Grumberg, and Doron Peled.
• Specifying software: A Hands-On Introduction, by R. D. Tennent.
• Research papers.

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 309 (JAN) 3:1

Topics in complexity theory

The theme of this course in the Jan-Apr 2016 semester is arithmetic circuit complexity. Arithmetic circuits are algebraic analogue of boolean circuits that naturally compute multivariate polynomials. The quest for a thorough understanding of the power and limitation of the model of arithmetic circuits (and its connection to boolean circuits) has lead researchers to several intriguing structural, lower bound and algorithmic results. These results have bolstered our knowledge by providing crucial insights into the nature of arithmetic circuits. Still, many of the fundamental questions/problems on arithmetic circuits have remained open till date.The aim of this course is to provide an introduction to this area of computational complexity theory. We plan to discuss several classical and contemporary results and learn about a wealth of mathematical (particularly, algebraic and combinatorial) techniques that form the heart of this subject.

Chandan Saha / Neeraj Kayal

Prerequisites

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

References: Current literature on Arithmetic circuit complexity.

E0 310 (JAN) 3:1

Advanced Software Engineering

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

Prerequisites

• Previous experience with building a system will be helpful but not essential.

References:

• 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.

E0 312 (AUG) 3:1

Secure Computation

Various models of secure computation, Computational/statistical indistinguishability Notions, Real/Ideal World security notions, Secret Sharing, Oblivious Transfer and its extension, Threshold Encryption, Secure computation with semi-honest security, Verifiable Secret Sharing, Commitment Schemes, Zero-knowledge Proofs, Secure computation with Active security, Broadcast & Byzantine Agreement (BA), Secure computation for the Cloud.

Arpita Patra

Prerequisites

• Mathematical maturity.
• Basic level crypto course
References:

• Book: “Efficient Two-part Protocols- Techniques and Constructions” by Carmit Hazay and Yehuda Lindell.
• Book Draft: “Secure Multiparty Computation and Secret Sharing - An Information Theoretic Approach” by Ronald Cramer, Ivan Damgaard and Jesper Buus Nielsen.
• Recent Research Papers

E0 323 (AUG) 3:1

Topics in Verification

In this course, we aim to study algorithmic approaches for automating 1. Synthesis of programs, 2. Discovering specifications of programs, 3. Selection of domain-specific algorithms. Along with presentations by course instructors, every participant will be assigned a few papers to be presented in the class. The exchange of knowledge will be mainly through open discussions in the classes. An optional course project will be offered for interested participants. The evaluation will be based on quality of presentations, understanding of material, and participation in the class discussions.

Aditya Kanade

Prerequisites

Program Analysis and Verification (E0 227) or Software
reliability techniques (E0 239); in other cases, you can seek permission from the instructors.

References:

A number of classic as well as recent research papers have been identified carefully. The list can be made available if required. There are no specific text book references for the course.

E0 330 (JAN) 3:1

Convex Optimization and Applications

The focus of the course will be on the fundamental aspects of convex analysis and optimization, both in terms of theory and algorithms. We will also look at various applications of convex optimization in inverse problems, signal processing, image reconstruction, communications, statistics, and machine learning. In the process of understanding the foundations of various algorithms, the students will be introduced to relevant topics in convex analysis and duality.

Topics : Review of relevant topics in real analysis, linear algebra, and topology. Topics in convex analysis: convex sets and functions, analytical and topological properties, projection onto convex sets, hyperplanes, separation theorems, sub-gradients, etc. Duality and its applications: Optimality conditions, duality, minimax theory, saddle points, KKT conditions. Canonical programs for constrained optimization: Linear programming, cone programming, and semidefinite programming. Classical algorithms: simplex, ellipsoid, and interior-point methods. Modern algorithms: accelerated gradient methods, proximal methods, FISTA, forward-backward splitting, augmented Lagrangian, ADMM, etc. Discussion of some of the popular applications of convex optimization.

Kunal Narayan Chaudhury.

References:
Boyd S and Vandenberghe L, Convex Optimization,Cambridge University Press, 2004.
Bertsekas D P, Convex Optimization Theory, Athena Scientific, 2009.
Bertsekas D P, Nonlinear Programming, Athena Scientific, 1999.

E0 331 (AUG) 3:1

Optimization for Machine Learning

Convex Optimization - Introduction, Incremental Gradient, Subgradient and Proximal Methods. Nonsmooth Convex Optimization, Lagrangian Relaxation - Dual Decomposition. Augmented Lagrangian Methods, Cutting Plane Methods, Large-Scale Learning - Approximate Optimization. Application/Measure Centric Optimization: distributed learning algorithms for linear and non-linear classifiers, optimization of performance measures such as precision@k, F-measure, AUC and partial AUC.

Shirish K. Shevade/ S. Sundararajan

Prerequisites: A course in Machine Learning or Data Mining.
References:

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

E0 335 (AUG) 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 Chatterjee

Prerequisites : Cryptography (E0 235).
• A selection of research papers from journals and conference proceedings.

E0 336 (JAN) 3:1

Topics in Cryptography - The Role of Randomness

Entropy notions such as min-entropy, shannon entropy etc. Computational variants of these notions and the challenges in analyzing them. Randomness extractors, privacy amplification protocols, leakage-resilient

Cryptography. Design of error correcting codes with specialized properties (motivated by various cryptographic applications) - e.g., non-malleable codes, updatable codes etc.

Bhavana Kanukurthi

Prerequisites
• An undergraduate course on Probability Theory will be helpful.
• Research papers.

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.

Matthew Jacob Thazhuthaveetil / R. Govindarajan

Prerequisites
• 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.

Uday Kumar Reddy B

Prerequisites
• Knowledge of "E0 255 Compiler Design" course content (especially on parallelization) will be very useful, but not absolutely necessary.
• Knowledge of microprocessor architecture and some basic understanding of parallel programming models.
References:
• Aho, Lam, Sethi, and Ullman, Compilers: Principles, Techniques, and Tools, 2nd edition
• Herlihy and Shavit, The Art of MultiProcessor Programming
• Ananth Grama, Introduction to Parallel Computing
• List of research papers and other material which will be the primary reference material will be available on course web page

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

Pre-requisite: Knowledge of Probability theory
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.

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

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

E1 222 (AUG) 3:0

Stochastic Models and Applications

Probability spaces, conditional probability, independence, random variables, distribution functions, multiple random variables and joint distributions. 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 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.

Prasanta Kumar Ghosh

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

PARIMAL PARAG

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.

ATIDYA GOPALAN

Probability/stochastic processes, linear algebra. General mathematical maturity.

Contents: 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.

E1 246 (AUG) 3:1

Natural Language Understanding

Motivation and objectives of the course : This course provides a modern and statistical perspective on natural language processing. The course will enable the student to: acquire fundamentals of language technology; understand, implement, and apply state-of-the-art techniques to novel problems involving natural language data; and be able to read and understand current research literature. Necessary machine learning concepts will be covered along the way.
Syllabus : Morphology, Parts-of-Speech, Language Models, Word Sense Disambiguation, Anaphora Resolution, Finite State Transducers, Basics of Supervised and Semi-supervised Learning, Hidden Markov Models, EM Algorithm, Structured Prediction, CFG Parsing, Dependency Parsing, Discourse Processing, Lexical Semantics, Distributional Semantics, Representation Learning for NLP, Semantic Parsing, Knowledge Bases, Topic Models, Machine Translation, Information Extraction, Sentiment analysis.

Partha Partim Talukdar

Prerequisites: Prior experience with programming Data structures & algorithms, machine learning will be helpful, (although not mandatory).

Chris Manning and Hinrich Schütze, Foundations of Statistical Natural Language Processing, MIT Press, May 1999.

Emily Bender, Linguistic Fundamental for NLP, Morgan Claypool Publishes, June 2013.

Jurafsky D, and Martin J H, Speech and language processing: an introduction to Natural language processing, computational linguistics and speech recognition, Pearson Education, 2003.
Allen J, Natural language understanding, Pearson Education, 2003. Research Literature

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

References:
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 (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

References:

• Roger B. Myerson, Game Theory: Analysis of Conflict, Harvard University Press, September 1997.
• Martin J. Osborne, An Introduction to Game Theory, Oxford University Press, 2003.
• Y. Narahari, Dinesh Garg, Ramasuri Narayanam, Hastagiri Prakash. Game Theoretic Problems in Network 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 problems; 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 277 (JAN) 3:1

Reinforcement Learning

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

Shalabh Bhatnagar

References:

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

E1 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

References:

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

E1 396 (AUG) 3:1

Topics in Stochastic Approximation Algorithms

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

Shalabh Bhatnagar

Prerequisites

• A basic course on probability theory and stochastic processes . References:

• H.J.Kushner and G.Yin, Stochastic approximation and recursive algorithms and applications (2nd edition), Springer Verlag, New York, 2003.
• A.Benveniste, M.Metiview and P.Priouret, Adaptive algorithms and stochastic approximation, Springer-Verlag,1990.
• V.S.Borkar,Stochastic Approximation: A Dynamical Systems Viewpoint, Hindustan Book Agency, 2008.
• D.P.Bertsekas and J.N.Tsitsiklis, Neuro-dynamic programming, Athena Scientific, 1996.
• Relevant research papers.

E2 Communication Systems

E2 201 (AUG) 3:0

Information Theory

Entropy, mutual information, other measures of information, source coding, hypothesis testing, channel capacity, channel coding theorems, applications of Fano's inequality in statistical learning, differential entropy, Gaussian channel, rate distortion theory.

HIMANSHU TYAGI

T. M. Cover and J. A. Thomas, Elements of Information Theory, 2nd edition, John Wiley & Sons, 2006.
T. S. Han, Information-Spectrum Method in Information Theory, Springer-Verlag Berlin Heidelberg, 2003.
I. Csiszar and J. Korner, Information Theory: Coding Theorems for Discrete Memoryless Systems, 2nd edition, Cambridge University Press, 2011.

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/NAVIN KASHYAP

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.

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 206 (JAN) 3:0

Information and Communication Complexity

Two parties observing inputs to a function seek to compute the value of the function. How many bits much they exchange? This basic problem, termed the communication complexity problem, was introduced in a seminal work of Yao in 1979 and has been studied extensive in the theoretical computer science community for the past four decades. Underlying this research impetus is the fundamental connection that the communication complexity problem shares with circuit complexity and space complexity for streaming algorithms. In this course we will review the various approaches for deriving bounds on communication complexity, with specific emphasis on information theoretic methods.

HIMANSHU TYAGI

E. Kushilevitz and N. Nisan, "Communication Complexity," Cambridge University Press, 2006

E2 208 (JAN) 3:0

Topics in Information Theory & Coding

Topics will be drawn from codes for distributed storage, low-density parity-check codes, polar codes and multi-terminal information theory. Further details on topic selection and relevant references will be provided closer to the start of the semester.

P VIJAY KUMAR

T. Cover and J. A. Thomas, Elements of Information Theory, John Wiley, (2nd Edition), 2006.

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

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

A G Ramakrishnan

References:
Horn, and Johnson, Matrix Analysis, Cambridge University press, 1985
Golub, and Van Loan, Matrix Computations, John Hopkins University Press, 1983
Gilbert Strang, Linear Algebra and its Applications, Fourth Edition, Thomson Brooks/Cole, 2006.

E2 213 (JAN) 3:0

Information - Theoretic Security

The Shannon secrecy system model, perfect secrecy. Discrete wiretap channels: rate-equivocation region, weak secrecy, strong secrecy, secrecy capacity, coding for wiretap channels. Secret-key agreement: source and channel models, weak and strong secret-key capacity, secret-key generation protocols, privacy amplification, balanced colouring lemmas, multiterminal SK agreement. Secrecy with Gaussian sources and channels, lattice coding for secrecy

NAVIN KASHYAP

M. Bloch and J. Barros, Physical-Layer Security, Cambridge University Press, 2011
I. Csiszar and J. Korner, Information Theory: Coding Theorems for Discrete Memoryless Systems, 2nd ed., Cambridge Univeristy Press, 2011.
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 222 (JAN) 3:0

Communication Networks Analysis

Introduction to the layered network architecture; Adaptive window flow control and TCP protocols; Scheduling in packet networks, max-weight scheduling, complexity, and distributed randomized algorithms; Routing protocols; MAC layer protocols in wireless networks; Scheduling in wireless networks; Throughput scaling laws for wireless networks; Network resource allocation, Interpretation of network architecture and algorithms in terms of optimization solution; Game-theoretic interpretation of optimization formulation and solution; A brief introduction to Peer-to-peer networks and Cloud networking.

Chandramani Singh

R. Srikant and L. Ying, Communication Networks: An Optimization, Control and Stochastic Networks Perspective, Cambridge University Press, 2014
Anurag Kumar, D. Manjunath, Joy Kuri, ``Communication Networking: An Analytical Approach," Morgan Kaufman Series in Networking, May 2004

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 230 (AUG) 3:0

Network Science and Modeling

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

Chandramani Singh

M. Newman. Networks: An Introduction. Oxford University Press, 2010.
D. Easley and J. Kleinberg, Networks, Crowds and Markets..

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

W. Richard Stevens, TCP/IP Illustrated, vol I: The Protocols, Pearson Education Asia, 2000
Douglas Comer, Internetworking with TCP/IP vol I: Principles, Protocols and Architecture, Prentice Hall, 4th Edition, 2000
Selected Internet RFCs (Request for Comments), available at http://www.ietf.org/rfc.html

E2 241 (JAN) 3:0

Wireless Networks

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

UTPAL MUKHERJI

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

E2 242 (JAN) 3:0

Multi-User Detection

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

A CHOCKALINGAM

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

E2 243 (AUG) 2:1

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, pseudo-inverse 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 251 (AUG) 3:0

Communications Systems Design

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

A. CHOCKALINGAM

Tony J. Rouphael, ``Wireless Receiver Architectures and Design: Antenna, RF, Synthesizers, Mixed Signal and Digital Signal Processing,'' Academic Press, 2014.
Lydi Smaini, ``RF Analog Impairments Modeling for Communication Systems Simulation: Application to OFDM-based Transceivers,'' John-Wiley & Sons, 2012.
Abbas Mohammadi and Fadhel M. Ghannouchi, ``RF Transceiver Design for MIMO Wireless Communications,'' Springer-Verlag, 2012.
Fa-Long Luo, ``Digital Front-End in Wireless Communications and Broadcasting: Circuits and Signal Processing,'' Cambridge Univ. Press, 2011.
Research papers.

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

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

NEELESH B MEHTA

Pre-requisite: E2 211 “Digital Communications”
References
Stefaniz Sesia, Issam Toufik, Matthew Baker, "LTE - The UMTS Long Term Evolution," John Wiley & Sons, 1st ed., 2009.
Andrea Goldsmith, “Wireless Communications,”, Cambridge University Press, 1st ed., 2005.
J. Proakis, “Digital Communications,” 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

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 illustrate the utility of random matrix theory in solving them.

CHANDRA R MURTHY

Prerequisites: Random Processes, Matrix Theory

References:
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," Now Publishers, 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 220 (AUG) 3:0

Foundations of Nanoelectronic Devices

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

KAUSIK MAJUNDAR

D. J. Griffiths, Introduction of Quantum Mechanics, Prentice Hall.
A. Ghatak and S. Lokanathan, Quantum Mechanics, Trinity Press.
V. K. Thankappan, Quantum Mechanics, New Age.
Solid State Physics, N. W. Ashcroft and N. D. Mermin.
S. M. Sze, Physics of Semiconductor devices, Wiley-Interscience.
Y. Taur and T. H. Ning, Fundamentals of modern VLSI devices, Cambridge University Press.

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 230 (AUG) 2:1

Essential Circuits for System Design

Analog Signal conditioning circuits: Buffering, scaling, level translation, filtering and applications Analog math circuits - arithmetic circuits, log circuits, trigonometric circuits and applications Timer circuits, pulse width modulation circuits, P, PI and PID controller circuits, protection circuits, base and gate drive circuits for power transistors, MOSFETs and IGBTs, relay and contactor drive circuits. Power supply circuits: Board level power supply circuits to generate +/-12V, 5V, 3.3V, 1.8V. Linear regulators, low drop out regulators, charge pumps, switched mode power converters. Interfacing circuits: A to D, D to A, A to A and D to D interfaces, serial and parallel DACs, sampling, RS-232, USB, I2C, LCD, serial memory, SPI, wireless, Ethernet, RFID, SD card, SIM card, GPS interfaces Digital circuit essentials: Digital filters, moving average, numeric formats, scaling, normalizing, arithmetic, log, exponential, square root, cube root, hypotenuse, sine, 3 phase waves, PWM etc. Laboratory: 6 sessions for Analog signal conditioning circuits, 4 sessions for power supply circuits and 8 sessions for interfacing circuits. For interfacing circuits, an 8-bit microcontroller with DIP package (probably in ATmega series) can be used so that students can rig up the circuits during lab sessions on general purpose boards.

L Umanand, N S Dinesh, Haresh Dagale

Data sheets, Application Notes

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 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
Behzad Razavi, RF Microelectronics
T. H. Lee, The design of CMOS Radio-frequency Integrated Circuits

E3 238 (AUG) 2:1

Analog VLSI Circuits

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

GAURAB BANERJEE

Behzad 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

References:
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 software development, S/W Development environment- Cross compiler, Linker, Debugger, Stand-alone systems; Introduction to embedded computing, Introduction to RISC architecture, Introduction to ARM Cortex architecture and ARM/THUMB instruction set, Clocks and Power Management, Low power design, Memories, application development, Peripherals.

Haresh Dagale

Alred Aho, Monica Lam, Ravi Sethi and Jeffery Ullman, Compliers Principles, Techniques and Tools, Pearson Education
John Levine, Linkers & Loaders, Morgan Kaufmann
ARM System Developer's Guide
Andrew N Sloss, Dominic Symes and Chris Wright, Designing and Optimizing System Software, Elsevier
Joseph Yiu, The Definitive Guide to the ARM® Cortex-M3, Newnes Publications
David A Patterson and John Hennessy, Computer Organization and Design, Morgan Kaufmann

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 co-design; performance of these systems - estimation of speed, throughput, power and energy consumption; hardware design elements - design, validation, and testing tools; software platforms – OS and applications, code optimization, validation and robust code generation; system integration, debugging and test methodology; tools for coding, debugging, optimization, and documentation; measurement of system performance, Linux distributions for embedded systems using tools from Yocto project; Creating virtual prototypes - hardware software emulation. Applications: Healthcare and home automation examples.

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 micro vias, 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 271 (JAN) 3:0

Reliability of Nanoscale Circuits and Systems

Carrier transport and carrier enerPhysics 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 gy 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

Mayank Shrivastava

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

Prerequisites:
Solid State device Physics
Basics of MOS and Bipolar junction transistors

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

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

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 280 (JAN) 3:0

Carrier Transport in Electronics Devices

Quantum foundation, k-space, Semi-classical electron dynamics, Fermi golden rule, Carrier scattering due to acoustic phonons, optical phonons, charged impurity etc, implications to mobility in MOSFET, Boltzmann transport, low and high field transport, quantum transport fundamentals, ballistic transport, non-equilibrium Green's function (NEGF) approach.

KAUSIK MAJUMDAR

M. Lundstrom, Fundamentals of Carrier Transport, Cambridge University Press.
S. Datta, Quantum Transport: Atoms to Transistors, Cambridge University Press.
A. Ghatak and S. Lokanathan, Quantum Mechanics, Trinity Press

E3 327 (JAN) 3:0

Nanoelectronics Device Technology

Non idealities in MOS structure, High-k dielectrics, 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

Text/Reference Books:
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)

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

References:
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) 3:0

Power System Dynamics and Control

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

Gurunath Gurrala / Indraneel Sen

References:
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

References:
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 232 (JAN) 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

References:
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

References:
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

References:
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 / P S Nagendra Rao

References:
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. 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

References:
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

References:
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

References:
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

References:
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

References:
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

References:
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 / Udaya Kumar

References:
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.
Bradwell A, “Electrical Insulation”, text book, Peter Peregrinus Ltd, London, UK, 1983
Recent Journal/ Conference and CIGRE publications.

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

References:
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 / Kaushik Basu

References:
Mohan N, Power Electronics; Principles, Analysis and Design , John Wiley, 1989.
Robert Ericson, Fundamentals of Power Electronics, Chapman & Hall, 1997
Umanand L, Power Electronics: Essentials and Applications, Wiley India, 2009

E6 202 (AUG) 2:1

Design of Power Converters

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

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

References:
Ranganathan V T, Electric Drives, Course Notes, IISc, 2005-06
Fitzgerald A E , Kingsley C Jr. and Umans S D, Electric Machinery, Tata McGraw Hill, 2003.
Leonhard W., Control of Electrical Drives, 3rd Edition, Springer
Miller T J E, Brushless Permanent-Magnet and Reluctance Motor Drives, Oxford Science Publications, 1989
Krishnan R, Permanent-Magnet-Synchronous and Brushless DC motor Drives, CRC Press, Taylor & Francis Group, 2010
Current Literature.

E6 212 (JAN) 2:1

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) 3:1

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

References: 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 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
References:
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/ E. S. 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-Optics 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

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

E8 201 (JAN) 3:0

Electromagnetism

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

Udaya Kumar

References:
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 203 (AUG) 3:0

RF and Optical Engineering

Fundamentals: Transmission lines & waveguiding structures, wave propagation, computational methods; dielectric waveguides, optical fibers, modern antennas. Elements of RF engineering: components, RF System design, millimeter & submillimeter (THz) wave systems, propagation models, applications. Optical Systems: fiber optic components, modulation techniques, system design, propagation effects-loss, dispersion, and non-linearities; long distance fiber optic links, wireless optical systems. Emerging Topics: metamaterials, photonic bandgap structures, plasmonics, microwave phonotics, RF over fiber, opto microwave signal generation; optical signal processing.

T SRINIVAS and K J VINOY

Millimeter Wave Wireless Communications by Theodore S. Rappaport, Robert W. Heath Jr., Robert C. Daniels and James N. Murdock
Fiber-Optic Communication Systems , by Govind P. Agrawal
Current literature

E8 242 (JAN) 2:1

Radio Frequency Integrated Circuits and Systems

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

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.

Soma Biswas

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

E9 202 (AUG) 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. 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; Lfilter, optimality. Myriad filtering. Non-linear filters based on Votterra series.

T. V. SREENIVAS

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: l1 minimization, null space property, necessary and sufficient conditions for l0 – l1 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.

K V S HARI

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

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

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.

Prasanta Kumar Ghosh

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

E9 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, commanding 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

Reference:
N. S. Jayant and P. Nill, 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

MIMO 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

Representation of two-dimensional signals; Sampling, quantization and reconstruction; Digital images; Human visual perception; Transforms: DFT, DCT, KLT, Wavelet; Filtering; Edge detection; Image restoration; Compression; Segmentation; Applications

Chandra Sekhar Seelamantula

References:
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, et al., Digital image processing using MATLAB, Prentice Hall, 2009.

E9 242 (AUG) 3:1

Selected Topics in Image Processing

Applications: Image
Denoising, Deblurring, Inpaiting,
Segmentation, Motion Estimation. Tools: Wavelets, Level Set Methods,
Non-Linear Diffusion and PDE's, Stochastic Models,
Kernel Methods, Variational Methods.

K R Ramakrishnan / Kunal Narayan Chaudhury

References:
Chan T. and Shen J., Image Processing and Analysis, SIAM, 2005.
Mallat S., A Wavelet Tour of Signal Processing (3rd edition), Academic Press, 2008.

E9 243 (AUG) 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

References:
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 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 / Muthuvel Arigovindan

References:
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 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.
References:
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 246 (JAN) 3:1

Advanced Image Processing

Feature descriptors including Harris corner detector, Scale Invariant Feature Transform (SIFT), SIFT-PCA, Speeded Up Robust Features (SURF), Extraction of edges, Canny edge detector, Hough Transform, generalized Hough transform, Image Segmentation - Graph-based techniques, Active Contours, Active Shape Models, Active Appearance Models, Mean Shift, Tracking - Kalman Filter, Particle Filter, Image Super-resolution from single and multiple images, Image Registration, Hidden Markov Models, Gaussian Mixture Models, EM algorithm, Applications: Face recognition, activity Classification, object recognition, shape matching, Some applications of Sparse Representation and Dictionary Learning in Image Processing

Soma Biswas

Pre-requisites: E9 241
References:
David A. Forsyth and Jean Ponce, Computer Vision: A Modern Approach, Pearson Education, 2003
Richard Szeliski, Computer Vision: Algorithms and Applications, Springer, 2010.
Simon J.D. Prince, Computer Vision: Models, Learning, and Inference, Cambridge University Press, 2012.
Current Literature.

E9 251 (JAN) 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 (JAN) 3:1

Speech Information Processing

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

Chandra Sekhar Seelamantula

Pre-requisites: E9-201 or consent of the instructor.
References:
Handbook of Speech Processing, Benesty, Jacob; Sondhi, M. M.; Huang, Yiteng (Eds.), Springer, 2008.
Gold B, and Morgan N, Speech and Audio Signal Processing, John Wiley, 2000.
Douglas O'shoughnessy, Speech Communication, IEEE Press 2000.
Taylor P, Text-to-Speech Synthesis, Cambridge Univ. Press, 2009.
Rabiner L R, and Schafer R W, Theory and applications of digital speech processing, Pearson, 2011.
Quatieri T F, Discrete-time speech signal processing, Prentice-Hall, 2002.
Recent literature.

E9 262 (JAN) 3:0

Stochastic Models for Language, Speech and Audio

Human speech communication, concept=> signal=> concept & levels of information. Discrete and continuous representations, signal representation as a pattern; 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 derivation; 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 introduction. 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 large vocabulary CSR. Linear Dynamical Systems and kalman filtering, relation to HMM.

T. V. SREENIVAS

Pre-requisite: E2-202 Random Processes or equivalent.
References:
* X. Huang and A. Acero and H. Hon: "Spoken Language Processing," Prentice Hall, 2001
+ Research papers
* C.M. Bishop: "Pattern Recognition and Machine learning," Springer, 2006.
* L.R. Rabiner and B.H. Juang: "Fundamentals of speech recognition," Prentice Hall, 1993.

E9 271 (AUG) 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
Introduction to Space-Time Wireless Communications, A. Paulraj, R. Nabar and D. Gore. Cambridge University Press, 2003.
Current literature

E9 282 (JAN) 2:1

Neural Signal Processing

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

Supratim Ray / Chandra Sekhar Seelamantula

References:
Kandel, Schwartz and Jessell. Principles of Neural Science, 4th Edition.
Buzsaki G, Rhythms of the brain, Oxford University Press, USA 2006.
Handbook of functional MRI data analysis, R. A. Poldrack, J. A. Mumford and T. E. Nichols, Cambridge University Press, New York, 2009.
Mallat S, A Wavelet Tour of Signal Processing - The sparse way, Elsevier, Third Edition, 2009
Thomas M. Cover and Joy A. Thomas, Elements of Information Theory, 2nd Edition, Wiley series in Telecommunications and Signal Processing, 1991.

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

References:
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.

EP 299 (JAN) 0:28

Project

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

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 Technology. 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	Earth Sciences
ME	Mechanical Engineering
MT	Materials Engineering
PD	Product Design and Manufacturing
ST	Sustainable Technologies

The first two digits of the course number have the departmental code as the prefix. All the Departments/Centres (except the Space Technology Cell) of the Division provide facilities for research work leading to the degrees of 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 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

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 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

Santosh Hemchandra or Swetaprovo Chaudhuri

References:

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

Pre-requisites: AE 246 or equivalent, AE 203 or equivalent. These can however be waived after discussion with the course instructors.
AE 245 (AUG) 3:0 Mechanics and Thermodynamics of Propulsion: S. Chaudhuri
AE 246 (JAN) 3:0 Combustion: KN Lakshmisha
AE 247(JAN) 3:0 Aircraft engine: T S Sheshadri or D Sivakumar
AE248(JAN)3:0 Rocket Propulsion: Charlie Oommen and N K S Rajan

AE 317 (AUG) 3:0

Aeroacoustics

Review of classical acoustics: linearized equations of motion; classical wave equation: plane and spherical waves, wave propagation in homogeneous and inhomogeneous media; models for acoustic sound sources: point sources, monopoles, dipoles and quadrupoles, Green's function solutions for wave equations,Kirchhoff-Helmholtz theorem for rigid boundaries. Aeroacoustic sources:Lighthill's acoustic enalogy, integral solutions and far-field approximations; effect of solid surface: Curle's theory and Ffowcs Williams-Hawkings' equation. Computational approaches: numerical aspects; direct methods: Reynolds-averaged Navier-Stockes equations (RANS), direct numerical simulations (DNS), application of large eddy simulations (LES); hybrid methods: flow-sound separation, numerical evaluation of Lighthill's integral.

Arnab Samanta

Preequisite: AE 203 or equivalent, consent of Instructor.
Literature: Pierce, A.D., Acoustics, Acoustical Society of America, 1989; Howe, M.S., Theory of Vortex sound, Cambridge, 2003; Crighton, D.G., Basic principles of aerodynamic noise generation, Prog. Aerospace Sci., 16(1), 1975, pp. 31-96; Crighton, D.G., Dowling, A.P.,Ffowcs Williams, J.E., Heckl, M. and Leppington, F.G., Modern methods in analytical acoustics, Springer, 1992. Lecture notes and current literature.

AE 364 (AUG) 3:0

Differential Geometric Techniques in Control

An introduction to differentiable manifolds, tangent vectors, Vector fields, co-vector fields, immenrsions and submersions, integral curves, push-forward and pull-back of vector fields, Lie groups, actions of groups, Lie algebras, adjoint co-adjoint maps, symmetries, Riemannian manifolds, the covariant derivative, the affine connection and geodesic motion. Stabilization of simple mechanical systems described on Riemannian manifolds.

Ravi Banavar

References:
F.Bullo and A.D. Lewis, Geometric Control of Mechanical Systems, Springer, 2005; DD Holm, T Schmah and C Stoica, Geometric Mechanics and Symmetry, Oxford University Press, 2009; A M Bloch, Nonholonomic Mechanics and Control, Srpinger, 2003

AE203 (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.

AE206 (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.

AE209 (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

AE211 (AUG) 3:0

Mathematical methods for Aerospace Engineers

Applied linear algebra and probability theory; Boundary value problems, Finite differences, and finite elements ; Fouries series, integrals, DFTs and FFTs; Initial value problems and their numerical solution; Solution of sparse systems; Calculus of variations and adjoint methods.

Kartik Venkatraman

G. Strang. Computational Science and Engineering . Wellesley-Cambridge Press, Wellesley, MA, USA, 2007.
G. Strang. Introduction to Applied Mathematics . Wellesley-Cambridge Press, Wellesley, MA, USA, 1986.

AE217 (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

AE220 (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,S N Omkar and O N Ramesh

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

AE224 (AUG) 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 Suha

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.

AE227 (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 MotionGenesisTM Kane, AUTOLEVTM MATHAMATICA® and MATLAB®. Overview of flexible multi-body dynamics and applications in aerospace vehicular dynamics.

Dineshkumar Harursampath

Kane, T., and Levinson, D., Dynamics Online: Theory and implementation with AUTOLEVTM. 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.

AE228 (AUG) 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.

AE232 (AUG) 3:0

Wave Propagation in Structures

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

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.

AE238 (AUG) 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.

AE241 (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.

AE245 (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.

Swetaprovo Chaudhuri

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.

AE249 (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.

AE259 (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.

M Seetharama Bhat 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

AE260 (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

AE261 (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.

AE265 (AUG) 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

AE266 (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.

AE271 (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 ? – VIII, Roskam Aviation and Engineering Corporation.
Thomas C Corke, Design of Aircraft, University of Notre Dame, Prentice Hall.
Books: Small Unmanned Aircraft, Randal.W.Beard, Princeton University Press, ISBN:978-0-691-14921-9; Modelling and Simulation of Aerospace Vehicle Dynamics, Peter.H.Zipfel, AIAA Education series

AE328 (AUG) 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.

AE330 (AUG) 3:0

Dynamics of flow past on oscillating wing

Equations of motion of fluid flow past oscillating wings; Oscillating wing fluid dynamics at low Reynolds numbers; Quasi-steady fluid dynamic models for oscillating wings; Panel methods for unsteady flow; Potential flow models flapping wings; Small perturbation theory for oscillating slender bodies of revolution; Discrete viscous vortex methods.

Kartik Venkatraman

Pre-requisite: A graduate course in fluid dynamics or aerodynamics

Tuncer Cebeci, Max Platzer, Hsun Chen, Kuo-cheng Chang, Jian P Shao, 2005, Analysis of low speed unsteady airfoil flows, Springer.
Childress, S., 1981, Mechanics of swimming and flying, Cambridge University Press.
Mueller, T. J., ed., 2001, Fixed and flapping wing aerodynamics, AIAA.
Select monographs and research papers on oscillating wing aerodynamics

AE357 (AUG) 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 317 (JAN) 3:0

Aeroacoustics

Review of classical acoustics: linearized equations of motion; classical wave equation: plane and spherical waves, wave propagation in homogeneous and inhomogeneous media; models for acoustic sound sources: point sources, monopoles, dipoles and quadrupoles, Green's function solutions for wave equations,Kirchhoff-Helmholtz theorem for rigid boundaries. Aeroacoustic sources:Lighthill's acoustic enalogy, integral solutions and far-field approximations; effect of solid surface: Curle's theory and Ffowcs Williams-Hawkings' equation. Computational approaches: numerical aspects; direct methods: Reynolds-averaged Navier-Stockes equations (RANS), direct numerical simulations (DNS), application of large eddy simulations (LES); hybrid methods: flow-sound separation, numerical evaluation of Lighthill's integral.

Arnab Samanta

Preequisite: AE 203 or equivalent, consent of Instructor. Literature: Pierce, A.D., Acoustics, Acoustical Society of America, 1989; Howe, M.S., Theory of Vortex sound, Cambridge, 2003; Crighton, D.G., Basic principles of aerodynamic noise generation, Prog. Aerospace Sci., 16(1), 1975, pp. 31-96; Crighton, D.G., Dowling, A.P.,Ffowcs Williams, J.E., Heckl, M. and Leppington, F.G., Modern methods in analytical acoustics, Springer, 1992. Lecture notes and current literature

AE 330 (JAN) 3:0

Dynamics of flow past an oscillating wing

Equations of motion of fluid flow past oscillating wings; Oscillating wing fluid dynamics at low Reynolds numbers; Quasi-steady fluid dynamic models for oscillating wings; Panel methods for unsteady flow; Potential flow models flapping wings; Small perturbation theory for oscillating slender

bodies of revolution; Discrete viscous vortex methods

Kartik Venkatraman

Pre-requisite: A graduate course in fluid dynamics or aerodynamics

Tuncer Cebeci, Max Platzer, Hsun Chen, Kuo-cheng Chang, Jian P Shao, 2005, Analysis of low speed unsteady airfoil flows, Springer.
Childress, S., 1981, Mechanics of swimming and flying, Cambridge University Press.
Mueller, T. J., ed., 2001, Fixed and flapping wing aerodynamics, AIAA.
Select monographs and research papers on oscillating wing aerodynamics

AE202 (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

AE204 (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

AE207 (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.

AE210 (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. AE
John D Anderson, Modern Compressible Flow, McGraw Hill, 1990.

AE214 (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.

AE216 (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.

AE218 (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.

AE219 (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.

AE223 (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.

AE224 (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 Suha

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.

AE228 (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.

AE230 (JAN) 3:0

Aeroelasticity

Effect of wing flexibility on lift distribution; Torsional wing divergence; Unsteady aerodynamics of oscillating wing; Bending-torsion flutter of wing sections and wings; Stall flutter, panel flutter, and transonic flutter; Gust response of elastic airplane; Aeroservoelasticity; Aeroelastic effects on aircraft stability derivatives; Flight dynamics and aeroelasticity

Kartik Venkatraman

Pre-requistes: A graduate course in mechanics—Solid or fluid or both.

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.

AE232 (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.

AE234 (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.

AE235 (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.

AE238 (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.

AE240 (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.

AE246 (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.

AE247 (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.

AE248 (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.

Charlie Oommen and NKS rajan

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.

AE258 (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 H8 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.

AE262 (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.

A Ratnoo and Debasish Ghose

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

AE265 (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

AE276 (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.

AE281 (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.

AE282 (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

AE299 (JAN) 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

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AE315 (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.

AE316 (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

AE328 (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.

AE355 (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.

AE357 (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.

AE360 (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.).

AE361 (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

AE362 (JAN) 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.

AE363 (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

Atmosheric and Oceanic Sciences

M Tech Programme in Climate Science

Duration: 2 years
Total Credits: 64

Core Courses: 21 Credits

AS 202 3:0 Geophysical Fluid Dynamics
AS 203 3:0 Atmospheric Thermodynamics
AS 204 3:0 Atmospheric Radiation and Climate
AS 205 3:0 **Atmosphere and Ocean 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 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 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 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 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 Satheesh

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 Srinivasan, G S Bhat, Arindam Chakraborty and Ra

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

AS205 (AUG) 2:1

Ocean Dynamics

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

P N Vinayachandran

Stewart, R.H., Introduction to Physical Oceanography, http://oceanworld.tamu.edu (online book)
Talley, L.D. Pickard, G.L., Emery, W.J., Descriptive Physical Oceanography, 6th Edn, Elsevier , 2011.
Gill, A.E., Atmosphere-Ocean Dynamics, Academic Press, 1982.
Cushman-Roisin, B., Introduction to Geophysical Fluid Dynamics, Prentice Hall, 1994.

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 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

AS 211 (AUG) 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.radiative transfer, the role of radiation in climate.

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 312 (JAN) 3:1

Earth System Modelling (JAN) 3:1 Pre-requisites: AS 202/205/207

Atmospheric Modelling: Equations used in atmospheric modelling, numerical discretization techniques: finite difference, finite volume, spectral techniques, temporal discretization. Modelling of sub-grid scale processes: cumulus parameterization and boundary layer parameterization.

Earth System Modelling: Radiative forcing, climate feedbacks, global and regional climate change, global carbon cycle, terrestrial and ocean carbon uptake and the carbon cycle feedback.

Ocean Modelling: Governing equations, initial and boundary conditions, approximations, 1-D ocean models, reduced gravity ocean models, primitive equation ocean models, sub-grid scale processes, applications.

Ravi S Nanjundiah, G. Bala and P. N. Vinayachandra

Kantha and Clayson, Numerical Models of Oceans and Oceanic Processes, Academic Press
B. Cushman-Roisin, Introduction to Geophysical Fluid Dynamics: Physical and Numerical Aspects, Academic Press, 2011.
T T Warner: Numerical Weather and Climate Prediction. Cambridge University Press, 2011

Civil Engineering

Annexure -1

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 evelopment

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 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

Annexure - 2

CIVIL ENGINEERING

Syllabus for Revised M.E. and M. Tech. Program (from August 2015)

M.E. Program in Civil Engineering

Semester 1 Common to all students

Core: 18 Credits
CE 201N 3:0 Basic Geomechanics
CE 202N 3:0 Foundation Engineering
CE 203N3:0 Hydrological Processes
CE 204N 3:0 Solid Mechanics
CE 205N3:0 Introduction to Finite Elements
MA------- 3:0 Math course

a) The 3:0 credits mathematics course will be identified by the Department at the beginning of the semester.
b) **To fulfill Major requirement in an Area,** students shall complete minimum 21 course credits (15 core + 6 elective) and 22 Dissertation project credits in the said Area.
c) **For optional Minor in one of the other two Areas**, a student must complete minimum of 12 credits in the said Area.

Major inGeotechnical Engineering

Core: 9 Credits

CE 206N 3:0 Earth and Earth Retaining Structures
CE 207N 3:0 Geoenvironmental Engineering
CE 208N 3:0 Ground Improvement and Geosynthetics
CE299N 0:22 Dissertation Project

Major in Structural Engineering

Core: 9 Credits

CE 209N 3:0 Mechanics of Structural Concrete
CE 210N 3:0 Structural Dynamics
CE 228N 3:0 Introduction to the Theory of Plasticity
CE299N 0:22 Dissertation Project

Major in Water Resources and Environmental Engineering

Core: 12 Credits

CE 212N 3:0 Computational Fluid Dynamics in Water Resources Engineering
CE 213N 3:0 Systems Techniques in WaterResources & Environmental Engineering
CE 214N 3:0 Water Quality Modeling
CE 215N 3:0 Stochastic Hydrology
CE299N 0:22 Dissertation Project

Electives inGeotechnical Engineering

CE 220N 3:0 Pozzolanic Stabilization of Soils
CE 221N 3:0 Earthquake Geotechnical Engineering
CE 222N 2:1 Fundamentals of Soil Behaviour
CE 223N 3:0 Soil Dynamics
CE 224N 2:1 Behaviour and Testing of Unsaturated Soils
CE 225N 3:0 Engineering Rock Mechanics
CE 226N 3:0 Computational Geotechnics
CE 227N 3:0 Engineering Seismology
CE 228N 3:0 Introduction to the Theory of Plasticity
CE 229N 3:0 Probabilistic Methods in Civil Engineering
CE 230N 3:0 Pavement Engineering

Electives inStructural Engineering

CE 235N 3:0 Optimization Methods
CE 237N 3:0 Nonlinear FEM in Structural Engineering
CE 238N 3:0 Structural Masonry
CE 239N 3:0 Stochastic Structural Dynamics
CE 240N 3.0 Uncertainty Modeling and Analysis
CE 241N 3:0 Random Vibrations and Structural Reliability
CE 242N (AUG) 3:0
An Elementary Overview of Numerical Methods in Mechanics and Engineering

Electives in Water Resources and Environmental Engineering

CE 245N 3:0 Design of Water Supply and Sewerage Systems
CE 246N 3:0 Urban Hydrology
CE 247N 3:0 Remote Sensing and GIS for Water Resources and Environmental Engineering
CE 248N 3:0 Regionalization in Hydrology and Water Resources Engineering
ME 201 3:0 Fluid Mechanics
AS216 3:0 Introduction to Climate Systems

M Tech Programme in Transportation and Infrastructure Engineering

Hard Core: 25 Credits (All courses are mandatory)

CE 230N 3:0 Pavement Engineering
CE 245N 3:0 Design of Water Supply and Sewerage Systems
CE 263 3:0 Modelling Transport and Traffic
CE 235N 3:0 Optimization Methods
CE 267 3:0 Transportation Statistics and Micro-simulation
ST 210 3:1 Principles and Applications of GIS and Remote Sensing
MA 261 3:0 Probability Models
CE 229N 3:0 Probabilistic Methods in Civil Engineering

Project: 22 credits

CE 299 0:22 Dissertation Project

Electives: 17 Credits of which at least 9 credits should be from among the electives listed below.

CE 202N 3:0 Foundation Engineering
CE 208N 3:0 Ground Improvement and Geosynthetics
CE 246N 3:0 Urban Hydrology
CE 209N 3:0 Mechanics of Structural Concrete

CE 205N 3:0 An Introduction to Finite Elements
ST 202 3:0 Renewable Energy – Technology, Economics and Environment
ST 203 3:0 Technology and Sustainable Development
MG 221 3:0 Applied Statistics
ST 211 3:0 Engineering Waste Management
CE 238N 3:0 Structural Masonry

Semester 1 (mandatory for all students)

CE 201N (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 202N (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 203N(AUG) 3:0 Hydrological Processes
Introduction to hydrological processes, Reynolds transport theorem, Energy & momentum principles, Hydrograph analysis, Flood routing, Hydrologic statistics and frequency analysis, Hydrologic design, Groundwater movement and balance, Equations of flow, Well hydraulics, Groundwater recharge estimation, Groundwater modeling.

V V Srinivas & M Sekhar

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.
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

CE 204N (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 205N (AUG) 3:0
An Introduction to Finite Elements

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.

Major in Geotechnical Engineering

CE 206N (Jan) 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 207N (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 208N (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.

Major in Structural Engineering

CE 209N (Jan) 3:0
Mechanics of Structural Concrete

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

J.M. Chandra Kishen& Ananth Ramaswamy

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 210N (Jan) 3:0
Structural Dynamics 3:0

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

C S Manohar

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

CE 228N (JAN) 3.0
Introduction to the Theory of Plasticity

1D plasticity and visco-plasticity; 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

Major in Water Resources and Environmental Engineering

CE 212N (Jan) 3:0
Computational Fluid Dynamics in Water Resources Engineering

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

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 213N (Jan) 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
Tata-McGraw Hill, 2005.

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

CE 214N (JAN) 3:0
Water Quality Modeling

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

M Sekhar

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

CE 215N (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

Electives in Geotechnical Engineering

CE 220N (AUG) 3:0
Pozzolanic Stabilization of Soils

Need for stabilization, Principles of soil stabilization, Different methods of stabilization, Pozzolanic stabilizations, Classification of soils for stabilisation, Different methods of stabilization. Mechanism of lime, cement stabilization, stabilization of soils with different solid waste materials such as fly ash, rice husk ash, ground granulated blast furnace slag etc. Design and Application of stabilizing agents, Stabilisation for different applications such as Embankments, excavations, Roads, problematic soils etc. Deep mixing and Grouting methods, Containment of Hazardous materials.

P V Sivapullaiah

Ingels O. G. and Metcalf, J. B. Soil stabilization, Principles and Practice, Butterworths, 1973.
Bowen , R. Grouting in Engineering Practice, Allied Publishers Ltd. 1975.
Broms, B. B. Stabilisation of soils with Lime Columns, Foundations Engineering Hand Book. Fang, H. Y. 1991. (ebook).
Karol R. H., Chemical Grouting and Soil Stabilisation, CRC Press, 2003.

CE 221N (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 222N (Jan) 2:1
Fundamentals of Soil Behaviour

Origin of soils, Identification and classification of clay minerals, Inter-particle forces, Soil structure, Soil - water interactions in the environment, Effective stress concepts and inter-particle forces, Role of clay mineralogy in engineering properties; hydraulic conductivity, consolidation, shear strength, Laboratory tests for identification of clay minerals, compaction, hydraulic conductivity, consolidation and shear strength.

M Sudhakar Rao & P Raghuveer Rao

Mitchell, J. K. Fundamentals of Soil Behaviour, John Wiley, 2005.
Yong, R. N. and Warkentin, B. P. Soil Properties and Behaviour, Elsevier, 1975,
Fang H.Y. and Daniels, J.L. Introductory Geotechnical Engineering - An Environmental Perspective, Taylor and Francis, 2006

CE 223N (AUG) 3:0
Soil Dynamics

Fundamental of vibrations; analysis of free and forced vibrations using spring dashpot model; equations' formulation and solution; 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; dynamic tests 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; assessment of zone of liquefaction. 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.

CE 224N (Aug) 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 determination of swell pressure, swell potential, collapse potential and soil suction of unsaturated soils.

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)

Lu, N. and Likos, W.J. Unsaturated soil mechanics (2004)

CE 225N (JAN) 3:0
Engineering Rock Mechanics

Rock as an engineering material, Geological factors affecting rocks, Stress, Strain and Strength of rocks, Insitu stresses in rock, Intact Rock - Elastic Deformation, Discontinuities and deformability and strength of rock masses, permeability, anisotropy and in homogeneity in rocks, Stereonet Analysis, testing techniques, rock mass classification, Failure criteria for rock and rock masses, Rock mechanics interactions and rock engineering systems, Excavation and stabilization principles, rock slope stability, foundations on rock, rock blasting support and reinforcement, Underground excavation and stability, Urban tunnels, Problematic Rocks - Rock Engineering, Modern modelling techniques & analyses in rocks.

T G Sitharam

Engineering Rock Mechanics: an Introduction to the Principles, 1997. Hudson J.A. and J.P. Harrison. Elsevier, Oxford
Introduction to Rock Mechanics by R.E.Goodman, John Wiley & Sons.
Engineering in Rocks for Slopes, Foundation and Tunnels, Editor T.Ramamurthy, Prentice Hall India Pvt. Ltd.
Additional Readings:
Additional literature, related codes and manuals from International Society of Rock Mechanics, ASTM and Bureau of Indian Standards

CE 226N (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 227N (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 228N (JAN) 3.0

Introduction to the Theory of Plasticity

1D plasticity and visco-plasticity; 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 229N (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 230N Pavement Engineering
(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.

Electives in Structural Engineering

CE 235N (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.

CE 237N (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.

CE238N (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 239N (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 240N (JAN) 3:0
Uncertainty Modeling and analysis

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

Debraj Ghosh

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 241N (AUG) 3:0

Random Vibrations and Structural Reliability

Review of probability: probability space, random variables, functions of random variables, sequence of random variables and limit theorems for sums, products and extremes. Review of random processes: stationarity, ergodictiy, power spectrum and autocovariance. Calculus of random processes. Input-output relations for linear systems. Stochastic steady state. Level crossing and first passage problems. Extreme value distributions. Reliability index based analyses: FORM and SORM. Monte Carlo simulations and variance reduction. Reliability of existing structures.

C.S. Manohar

A Papoulis, 1991, Probability, random variables and stochastic processes, 3rd Edition, McGraw-Hill, New York.
T T Soong and M Grigoriu, 1993, Random vibration of mechanical and structural systems, Prentice Hall, Englewood Cliffs.
R E Melchers, 1999, Structural reliability: analysis and prediction, 2nd Edition, John Wiley, Chichester.

CE 242N (AUG) 3:0
An Elementary Overview of Numerical Methods in Mechanics and Engineering

Vector spaces, representations of linear transformations, elements of matrix algebra, linear equations including under- and over-determined systems, eigenvalue problems and numerical schemes, singular value decomposition, generalized inverses, fixed-point methods, Jacobi and Gauss-Seidel methods, conjugate-direction methods, linear second order ODEs with constant coefficients, undetermined coefficients and variation of parameters, linear mechanical oscillators in single and multi-degrees of freedom, nonlinear autonomous ODEs, introduction to elliptic, hyperbolic and parabolic partial differential equations, the concept of weak solutions, elements of the finite element discretization applied to bars, beams and linear elasticity problems

D Roy

Bau III, David, and Lloyd N. Trefethen. *Numerical Linear Algebra*. Philadelphia, PA: Society for Industrial and Applied Mathematics, 1997.
Edwards, C., and D. Penney. *Elementary Differential Equations with Boundary Value Problems*. 6th ed. Upper Saddle River, NJ: Prentice Hall, 2003.

Quarteroni, A., and A. Valli. *Numerical Approximation of Partial Differential Equations*. Berlin; New York, NY: Springer-Verlag, 1997

Electives in Water Resources and Environmental Engineering

CE 245N (Aug) 3:0
Design of Water Supply and Sewerage Systems

Basics of hydraulics and hydrology. Introductory chemistry and biology. Water distribution systems, water processing, and 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 246N (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 247N (AUG) 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 248N (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 hydro-meteorological variables and extreme events. Regional homogeneity tests. Prediction of hydro-meteorological

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 203N

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.

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 299N 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 235 (AUG) 3:0

Modelling 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.

CH201 (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)

CH202 (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.

CH203 (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.

CH204 (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

CH237 (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.

CH242 (AUG) 3:0

Special Tpics 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

CH244 (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.

CH205 (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, attainable region analysis, 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.

CH206 (JAN) 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 S Venugopal

CH207 (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

CH234 (JAN) 3:0

Rheology of Complex Fluids and Particulate Materials

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

Prabhu R Nott

Larson, R., The Structure and Rheology of Complex Fluids, Oxford, 1999
Bird, R. B., Armstrong, R. C. and Hassager, O., Dynamics of Polymeric Liquids - Vol.1 Fluid Mechanics, Wiley, 1987
Rao, K. K. and Nott, P. R., An Introduction to Granular Flow, Cambridge, 2008.

CH236 (JAN) 3:0

Statistical Thermodynamics

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

Sudeep Punnathanam and K G Ayappa

McQuarrie, D.A., Statistical Mechanics, Viva Books, 2003.
Hill, T. L., An Introduction to Statistical Thermodynamics, Dover Publications, 1986
Chandler, D, Introduction to Modern Statistical Mechanics, Oxford University Press, New York, 1986

CH245 (JAN) 3:0

Interfacial and Colloidal Phenomena

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

Sanjeev K Gupta

Israelachvili, J., Intermolecular and Surface Forces, Academic, Press, 3rd edition, 2011.
Hunter, R. J., Foundations of Colloid Science, Vol. I, II Oxford, University Press, 1986.
Newman, John and Thomas-Alyea, K. E., Electrochemical Systems, 3rd edition, John Wiley and Sons, 2004.
Adamson, A. W. and Gast, A., Physical Chemistry of Surfaces, 6th edition, John Wiley and Sons, 1997.
Miller, C. A. and Neyogi, P., Interfacial Phenomena: Equilibrium and Dynamic Effects, Marcel Dekker, 1985.
Current literature and lecture notes given by instructor.

CH299 (JAN) 0:32

Dissertation Project

The ME project is aimed at training the students to analyze independently any problem posed to them. The project may 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

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 18 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,R N Govardhan and G Tomar

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 area defects in crystal structure. Solidification of metals, phase diagrams, Dislocation concepts of plastic deformation, critical resolved shear stress, interactions between dislocations and work hardening, Recovery, recrystallization and grain growth. Fracture-microscopic descriptions. Mechanisms of metal deformation, 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 Com pany, 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) 3:0

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 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 Emam i-Naeini, Feedback Control of Dynamic Systems, Addison W esley, 1987.

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.

R Narasimhan

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 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 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 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 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 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. W ylie, 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. Ba

Van Wylen, G.J., and Sonntag, R.E., Fundamentals of Classical Thermodynamics, Wiley. Wark, K., Advanced Thermodynamics for Engineers, McGraw Hill, 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

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

Mort on, 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 text s 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 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 Beckm an, W.A., Solar Engineering of Thermal Processes, John W iley 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 294 (AUG) 3:0

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) 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 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 241 (JAN) 3:0

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 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 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 W iley, 1982. Williams, E., Fourier Acoustics

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, W iley, 2000.

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 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. Goldst ein, M.F., Aeroacoustics, McGraw Hill, 1976.

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.

Pradip 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 W iley.

ME 275 (JAN) 3:0

Conduction and Radiation 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

Siegel, R., and Howell, J., Thermal Radiation Heat Transfer, Taylor and Francis, 2002. Hott el, 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 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 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., Therm al Environm ent al Engineering, Prentice Hall, Inc., Englewood Cliffs, New Jersey, 1970. ASHRAE Handbooks (SI Editions): Fundam entals (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.
Croom e, 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 Syst ems 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 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. Fom enko, A.T., and Kunii, T.L., Topological Modeling for Visualization, Springer - Verlag, 1997.

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.

J H 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 (JAN) 6:0

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 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.

V.A. Seethuraman

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 206 (AUG) 3:0

Texture and Grain Boundary Engineering

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

S SUWAS

M. Hatherly and W.B. Hutchinson, An Introduction to Textures in Metals (Monograph No. 5), The Institute of Metals, London.
V. Randle and O. Engler, Introduction to Texture Analysis: Macrotexture, Microtexture and orientation mapping, Gordon and Breach Science Publishers.
F.J. Humphreys and M. Hatherly, Recrystallisation and Related Phenomenon, Pergamon Press.
P.E.J. Flewitt, R.K. Wild, Grain Boundaries.

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 simulations in Materials Engineering; Numerical solution of ODes and PDes, explicit and implicit methods;Concepts of diffusion, phase-field technique, modeling of diffusive coupled phase transformations, spinodal decomposition. Level-set methods, Cellula Automata: simple models for simulating microstructures. Finite element modeling: Examples in 1D, variational approach, interpolation functions for simple geometries (rectangular and triangular elements); Atomistic modeling techniques: Molecular dynamics and Monte-Carlo Methods.

All course elements will involve some amount of coding simple examples, generation of data and post-processing.

A.N. Choudhury,Praveen Kumar

A.B. Shiflet and G.W. Shiflet: Introduction to Computational Science: Modeling and Simulation for the Sciences, Princeton University Press, 2006.

D.C. Rapaport: The Art of Molecular Dynamics Simulation, Cambridge Univ. Press, 1995.

K. Binder, D. W. Heermann: Monte Carlo Simulation in Statistical Physics, Springer, 1997.

K.G.F Janssens, D. Raabe, E. Kozeschnik, M.A. Miodownik, B. Nestler: Computational Materials Engineering: An Introduction to Microstructure Evolution, Elsevier Academic press, 2007.

David V. Hutton: Fundamentals of Finite Element Analysis

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 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 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 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 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 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 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 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 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 225 (JAN) 3:0

Deformation and Failure Mechanisms at Elevated Temperatures

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

A H Chokshi

Polreer, J.P., Creep of crystals, Cambridge University Press,
Cambridge, 1984.Riedel, H., Fracture at high temperatures, Springer
Verlag, Berlin, 1987.

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.

MT233 (JAN) 3:0

INTRODUCTION TO ELECTROCHEMICAL ENGINEERING

Course Description: This course will expose the student to a mathematical treatment of the following: Ion-solvent interactions; Ion-ion interactions; Interfaces: metal-electrolyte, and semiconductor-electrolyte; Electrical double layer; Thermodynamics of ideally polarizable and non-polarizable interfaces; Potential and charge distribution across the interface; Electrode kinetics; and Electrocapillarity. With a working knowledge of these fundamentals, the student will then be introduced to the following sub-branches of electrochemistry: Electrochemical energy-storage and energy-conversion devices; Corrosion and material protection; Electro-metallurgy (aqueous and non-aqueous); Electrodeposition;Electrocatalysis; Semiconductors; Photovoltaics; and Biosensors.

Vijay A Sethuraman

Prerequisites: Basic calculus; Introductory thermodynamics

Textbooks:
1. Electrochemical Systems, 3rd Edition, J. Newman and K.E. Thomas-Alyea, Wiley 2004. ISBN: 0471477567
2. Electrochemical Methods: Fundamental and Application, 2nd Edition, A.J. Bard and L.R. Faulkner, Wiley India 2006. ISBN: 8126508078
3. Modern Electrochemistry, Volume 1: Ionics, 2nd Edition, J.O'M. Bockris and A.K.N. Reddy, Springer 2006. ISBN: 8181284755
4. Modern Electrochemistry, Volume 2A: Fundamentals of Electrodics, 2nd Edition, J.O'M. Bockris, A.K.N. Reddy, and M.E. Gamboa-Aldeco, Springer 2006. ISBN: 8181284739
5. Modern Electrochemistry, Volume 2B: Electrodics in Chemistry, Engineering, Biology and Environmental Science, 2nd Edition, J.O'M. Bockris, A.K.N. Reddy, and M.E. Gamboa-Aldeco, Springer 2001. ISBN: 8181284747

Note: Handouts/lecture notes will be provided to students.

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 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 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 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 299 (JAN) 0:32

Dissertation Project

The M.E. Project is aimed at training the students to analyse independently any problem posed to them. The project may be a purely analytical piece of work. a completely experimental one or a combination of both. In a few cases. the project can also involve a sophisticated design work. The

project report is expected to show clarity of thought and expression. critical appreciation of the existing literature and analytical and/or experimental or design skill.

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.

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

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

Satish 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.

N D Shivakumar

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 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 219 (AUG) 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 231 (AUG) 2:1

Applied Ergonomics

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

Dibakar Sen

Sanders and McCormick, Human Factors in Engineering and Design, Seventh Edn, McGraw Hill, 1992.
Eberts, R.E., User Interface Design, Prentice Hall, 1994.

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.

Faculty

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.

N D Shivakumar

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.

B Gurumoorthy

Zeid, I., CAD/CAM, McGraw Hill

PD 215 (JAN) 2:1

Mechatronics

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

Faculty

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 (JAN) 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 (JAN) 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.

Faculty

Oakley, M. (Ed), Design Management – A Handbook of Issues and Methods, Blackwell Publication

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 (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 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

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 (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 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.

ST 203 (AUG) 3:0

Design, Technology and Sustainability

Development and sustainability: definitions, dimensions, interpretations, concepts, principles and indicators. Current issues and debates (case studies and assignment). Design and Technology: 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 (design/technology mini-project).

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

Dasappa, Monto, Chanakya, Somashekar, V Reddy

Current literature.

ST 210 (AUG) 3:1

Principles and Applications of GIS and Remote Sensing

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

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.

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 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 (JAN) 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.

Earth Sciences

CE 247N (AUG) 3:0

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

Attreyee Ghosh

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 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 201 (AUG) 2:1

Introduction to Earth System Science

Earth system processes, Timescale of interaction, chemical composition of geo-spheres, Landforms, Role of sun and earth's internal energy in driving the Earth system processes, Glaciations and de-glaciations cycles, habitable planet, evolution of earth through time, study of rock records, concept of snowball and slush ball earth, general circulation of ocean, explosion of life, fossilization, reconstruction of geological record, geological time scales, early life, extinction, asteroid impact, life evolution, mutation, synthesis of bio-molecule and bio-diversification, Gaia hypothesis, modern climate, role of tectonic and weathering in global climate, Indian monsoon and its variability, technique to study paleoclimate record, different archive for reconstruction of past climate, seasonality in palaeo-monsoon record.

Practical: Project on the model of real-world ecosystems in order to understand how biotic and abiotic factors interact and to see how one type of ecosystem impacts other ecosystems

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

Introduction to processes shaping the earth; developing chronological constraints.Reference frames and map projections, shape of the earth, Earth's gravity field, geodesy, isostasy. Earth's magnetic field, paleomagnetism, geomagnetic reversals.Plate tectonics, evolution of landforms and global seismicity. Earthquake types and quantification, interpreting seismograms, seismic waves and earth's interior, earthquake source characterization, earthquake and faulting processes; types of faults and relation to stress fields, moment tensors and earthquake focal mechanisms.Effects of earthquakes, earthquakes in Indian context, Structure of the Earth's interior- density, seismic velocity, pressure and temperature.Lab and field components: Handling earthquake recorders and data acquisition, Seismic Analysis Code and GMT for analyzing and representing global seismicity data.

Kusala Rajendran

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
Hugh Rollinson, Using Geochemical Data: Evaluation, Presentation and Interpretation, Longman Group, 1993
John D. Winter, Principles of Igneous and Metamorphic Petrology, 2nd edition, Pearson Prentice Hall, 2010
Charles H. Langmuir and Wally Broecker, How to build a habitable planet, Revised and expanded edition, Princeton University Press, 2012

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 (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

Biogeochemical processes and cycles in Earth system; biogeochemical reconstruction from continental and marine strata; thermodynamics and rate of chemical reactions, composition of surface water; evolution of seawater composition through time; principles of stable isotope fractionation ; geochemical cycles of C, O, N, S, Si; tracing the rise of oxygen using stable isotope proxies particularly S, Fe, Mo.

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.
Research papers from journals

ES 210 (JAN) 3:0

Tectonics and Crustal Evolution

Introduction to the theory of plate tectonics, application to understanding the structure, evolution and

dynamic processes of the earth. Plate motions on flat and spherical earth, evolution and stability of triple junctions, plate driving forces, seismicity and volcanism as a consequence of plate motions, evolution of landforms, mountain building, paleomagnetism and reconstruction of continental masses, plate tectonics through time. Evolution of Indian plate through time, dynamics of its plate boundaries; earthquakes as a tool to understand processes along plate boundaries.

Kusala Rajendran

Philip Keary, Keith A. Kelpeis and Frederick J. Vine, Global tectonics, Wiley-Blackwell, Third edition.
Fowler, C.M.R., The Solid Earth: An Introduction to Global Geophysics, Cambridge University Press, Second edition

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 213 (JAN) 3:0

Isotope Geochemistry

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

Ramananda Chakrabarti

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

ES 214 (AUG) 3:0

Topics in stratigraphy and geochronology

C-S-Sr isotope stratigraphy, time-series chemostratigraphic correlation, time-series Litho stratigraphic correlation, Biostraigraphic correlation, Magnetostratigraphy, Non-traditional isotope stratigraphy, Stratigraphy on Mars Zircon texture, morphology, zoning, Zircon as an equilibrium mineral, U-Pb dating of Zircon, REE in zircon, Th/U ratio in Zircon,

Hf in zircon, U-Pb dating methods, plotting and interpretation of ages, connecting age to tectonics

Sajeev Krishnan and Prosenjit Ghosh

Grastein,Ogg and Schmitz, The Geologic Time Scale 2012 2-Volume Set, 1st Edition,ISBN: 9780444594488
Ramkumar, M, Chemostratigraphy, Concepts, Techniques, and Applications, ISBM: 9780124199828, 2015
Simon L. Harley and Nigel M. Kelly, Zircon Tiny but Timely: Zircon Tiny but Timely , ELEMENTS, v. 3, p. (1): 13-18. February 2007
Zircon, John M. Hanchar and Paul W.O. Hoskin, editors, Reviews in Mineralogy and Geochemistry, Volume 53, 2003
Vance, D., Geochronology: Linking the Isotope Record With Petrology And Textures, Geological Society Special Publication, January 1, 2003

Division of Interdisciplinary Research

Preface

The Division of Interdisciplinary Research consists of the Bio-Engineering (BE), Interdisciplinary Centre for Energy Research (ER), Centre for Nano Science and Engineering (CeNSE), Centre for Infrastructure, Sustainable Transportation and Urban Planning (CiSTUP), Departments of Management Studies (MS), Robert Bosch Centre for Cyber Physical Systems and Supercomputer Education and Research Centre. The courses offered in the different departments of the Division have been reorganized after review and revision, and have been grouped department wise. These are identified by the following code.

BE	Biosystems Science & Engineering
ER	Energy Research
NE	Nano Science and Engineering
UP	Infrastructure,Sustainable Transportation and Urban Planning
MS	Departments of Management Studies,
SE	Supercomputer Education and Research Centre

The first two digits of the course number have the departmental code as the prefix. All the Departments/Centres of the Division provide facilities for research work leading to the degrees of M Tech, M Tech (Research) and PhD. There are specific requirements for completing a Research Training Programme for students registered for research at the Institute. For individual requirements, students are advised to consult the Departmental Curriculum Committee. The M Tech Degree Programmes are offered in Centre for Nano Science and Engineering, Supercomputer Education and Research Centre. 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. G Rangarajan
Chairman
Division of Interdisciplinary Research

BE 201 (AUG) 3:0

Fundamental of Biomaterials and Living Matter

at various length scales, Importance of material properties in the context of Biocompatibility, Basic concepts in Biomaterials Science; Bonding in materials, Structure-Property correlation; Structure of Materials 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.

Basu: Bikramjit

1. William. D. Callister, Jr. and David G. Rethwisch: Fundamentals of Materials Science: An Integrated approach: 4th Edition; John Wiley & Sons, 2011
2. B. Basu, D. Katti and Ashok Kumar; Advanced Biomaterials: Fundamentals, Processing and Applications; John Wiley & Sons, Inc., USA, 2009.
3. Biomaterials Science: An introduction to Materials in Medicine, Edited by Ratnes, Hoffman, Schoet and Lemons, Second Edition: Elsevier Academic Press, 2004.
4. Bikramjit Basu and Kantesh Balani; Advanced Structural Ceramics; John Wiley & Sons, Inc., USA and American Ceramic Society, 2011.
5. Fredrick H. Silver and David L. Christiansen, Biomaterials Science and Biocompatibility, Springer, Piscataway, New Jersey, first edition, 1999.
6. Janathan Black, Biological Performance of Materials: Fundamentals of Biocompatibility, Marcel Dekker, Inc., New York and Basel, 1999.

BE 203 (AUG) 0:1

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 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

1. B. Alberts, A. Johnson, J. Lewis, M. Raff, K. Roberts, and P. Walter, Molecular Biology of the Cell, Garland Science, New York, 2007.
2. J. Kuriyan, B. Konforti, and D. Wemmer, The Molecules of Life: Physical and Chemical Principles, Garland Science, New York, 2012.
3. M. H. Ross and W. Pawlina, Histology: A text and Atlas, Lippincott Williams and Wilkins, New York, 2011.
4. J. E. Hall, Guyton and Hall Textbook of Medical Physiology, Saunders Elsevier, Philadelphia, 2011.

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
R

1. Introduction to Chemical Engineering Thermodynamics, J. M. Smith, H. C. Van Ness and M. M. Abbott, Mc Graw-Hill, 2005.
2. Biological Thermodynamics, D. T. Haynie, Cambridge University Press, 2008.
3. Transport Phenomena, R. B. Bird, W. E. Stewart, E. N. Lightfoot, Wiley India, 2006
4. Transport Processes in Biological Systems, G. A. Truskey, F. Yuan and D. F. Katz, Pearson Prentice Hall, 2010

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

1. S. A. Berger, W. Goldsmith, and E. R. Lewis (Ed.), Introduction to Bioengineering, Chapter 1: Biomechanics of Solids, Oxford University Press, Oxford, 1996.
2. J. D. Humphrey and S. L. Delange, An Introduction to Biomechanics: solids and Fluids, Analysis and Design, Springer, Berlin, 2004.
3. D. Boal, Mechanics of the Cell, Cambridge University Press, Cambridge, 2001.
4. P. Nelson, Biological Physics, W. H. Freeman & Company, 2007.
5. J. Howard, Mechanics of Motor Proteins and the Cytoskeleton, Sinauer Associates, Inc., Sunderland, MA, USA, 2001.

Interdisciplinary Centre for Energy Research

ER 201 (AUG) 3:0

Energy Research

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 Ramamurt

ER 202 (JAN) 2:1

Energy Conversion, Power Transmission and Distribution

Overview of primary and renewable energy sources, installed capacity and projected growth, applications, advantages and limitations. Energy conversion: Solar, wind, micro-hydro etc, system control requirements, grid connectivity issues. Recent advances in power transmission, introduction to EHV/UHV AC and DC transmission systems; present status and future growth. Design criteria for overhead transmission lines: general system design, methodology, components of HV transmission systems, types of conductors/accessories and 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 HV Substations, Comparison of AIS, Hybrid-AIS and GIS, Insulation coordination for UHV systems, earthing and safety measures in UHV substations, Sub-station automation, power distribution, distribution reforms, SCADA.
Laboratory experiments on concepts in generation of primary and renewable energy sources, Assignments involving computation/simulation of ground end electric and magnetic fields, technical visits to Industry/HV Substation.

Subba Reddy B and L Umanand

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 ntellectual 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 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.

Faculty

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, (3rdEdn.), 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, chi-square-test, F-test, Sign Test, Wilcoxon Rank–Sum and Signed-Rank test. chi square-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 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 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 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, 5th Edition, 2014.
R. Srinivasan, Case Studies in Marketing – The Indian Context, Prentice-Hall of India, 6th Edition, 2014

MG 244 (AUG) 3:0

Services Marketing

Basic issues, conceptual framework, service strategy, service design and mapping, perceived service quality. SERVQUAL 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, 4th Edition, 2014.
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.

Faculty

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 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.

Faculty

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 298 (AUG) 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 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.

M H Bala Subrahmanya

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.

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

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 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 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 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, 2014.
R. Srinivasan, Case Studies in Marketing – The Indian Context, Prentice-Hall of India, 6th Edition, 2014.

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, 4th Edition, 2012.
R. Srinivasan, Case Studies in Marketing – The Indian Context, Prentice-Hall of India, 6th Edition, 2014.

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 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 286 (JAN) 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.

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 dont's of the English language will be dealt with as a part of the course. Assignments will include writing on topics to a student's research interest, so that the course may benefit each students directly.

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

Lecture notes

NE 201 (AUG) 2:1

Micro and Nano Characterization Methods

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

Akshay Naik/
Manoj Varma

Lecture notes and hands-on training manuals

NE 201 (JAN) 2:1

Micro and Nano Characterization Methods

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

Akshay Naik/
Manoj Varma

Lecture notes and hands-on training manuals

NE 202 (AUG) 0:1

Micro AND Nano Fabrication

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

Shankar Kumar Selvaraja/Sushobhan Avasthi

Handouts on detailed process flows and device characterization schedule

NE 202 (JAN) 0:1

Micro AND Nano Fabrication

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Shankar Kumar Selvaraja/Sushobhan Avasthi

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/
Digbijoy N Nath

Streetman and Banerjee ,Solid State Electronic Devices, Prentice-Hall

NE 211 (JAN) 3:0

Micro/Nano Mechanics

This is a foundation level course in mechanics which will prepare students to pursue advanced studies related to mechanical phenomena at the micro and nano scales. Basics of continuum theory, continuum hypothesis, elasticity, thermoelasticity, fluid mechanics, heat conduction, electromagnetism, coupled thermal-elastic and electrostatic-elastic systems, MEMS and NEMS structures -- beams, plates, and membranes, scaling of mechanical properties and continuum limits, numerical methods for mechanical modelling, mechanics beyond continuum theory.

Rudra Pratap
Akshay Naik

Prosenjit Sen

John A. Palesko and David H. Bernstein, Modeling MEMS and NEMS, Chapman and Hall/CRC

NE 213 (AUG) 3:0

Introduction to Photonics

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

Manoj Varma
Ambarish Ghosh

Bahaa Saleh and Malvin Teich, Fundamentals of Photonics, Wiley and Son (1991) Hecht E, Optics. Addison Wesley, 2001

NE 215 (AUG) 3:0

Applied Solid State Physics

This course is intended to build a basic understanding of solid state science, on which much of modern device technology is built, and therefore includes elementary quantum mechanics. Review of Quantum Mechanics and solid state physics, Solution of Schrodinger equation for band structure, crystal potentials leading to crystal structure, reciprocal lattice, structure-property correlation, Crystal structures and defects, X-ray diffraction, lattice dynamics, Quantum mechanics and statistical mechanics, thermal properties, electrons in metals, semiconductors and insulators, magnetic properties, dielectric properties, confinement effects

Akshay Naik/
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/
ProsenjitS

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 (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. Familiarity with solution of ODEs and PDEs, knowledge of Matlab, Mathematica or an equivalent programming language, elementary probability theory

NE203 (AUG) 3:0

Advanced micro- and nanofabrication technology and process

Introduction and overview of micro and nano fabrication technology. Safety and contamination issues in a cleanroom. Overview of cleanroom hazards. Basic process flow structuring. Wafer type selection and cleaning methods. Additive fabrication processes. Material deposition methods. Overview of physical vapour deposition methods (thermal, e-beam, molecular beam evaporation) and chemical vapour deposition methods (PE-CVD, MOCVD, CBE, ALD). Pulsed laser deposition (PLD), pulsed electron deposition (PED). Doping: diffusion and ion implant techniques. Optical lithography fundamentals, contact lithography, stepper/canner lithography, holographic lithography, direct-laser writing. Lithography enhancement methods and lithography modelling. Non-optical lithography; E-beam lithography, ion beam patterning, bottom-up patterning techniques. Etching process: dry and wet. Wet etch fundamentals, isotropic, directional and anisotropic processes. Dry etching process fundamentals, plasma assisted etch process, Deep Reactive Ion Etching (DRIE), Through Silicon Vias (TSV). Isotropic release etch. Chemical-mechanical polishing (CMP), lapping and polishing. Packaging and assembly, protective encapsulating materials and their deposition. Wafer dicing, scribing and cleaving. Mechanical scribing and laser scribing, Wafer bonding, die-bonding. Wire bonding, die-bonding. Chip-mounting techniques.

Shankar Kumar Selvaraja/ Sushobhan Avasthi

Marc J. Madou,Fundamentals of Microfabrication and Nanotechnology, CRC press, ISBN 9780849331800,
Handouts and Lecture notes,
Research articles

NE310 (JAN) 3:0

Photonics technology: Materials and Devices

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

Shankar Kumar Selvaraja

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

NE312 (AUG) 3:0

Nonlinear Photonics and Lasers

Classical theory of nonlinear optical interactions, Intensity dependent refractive index, Molecular origins of Nonlinear optical response, Nonlinear effects from various orders of susceptibilities, Photon-phonon scattering, Electro and Acousto-Optic effects, Non-linear optics in guided wave devices, Self-phase/Cross-phase modulation, Solitons, Four-wave mixing, Stimulated Raman/Brillouin scattering, Basic Laser principles, Rate equations, Optical beams and resonators, Laser cavities and feedback, Laser dynamics, Survey of important laser technologies, Nonlinear optical effects in lasers, Optical Communication Amplifiers, Q-switching, Mode-locking, A brief introduction to ultrafast optics.

V. R. Supradeepa

Robert W. Boyd, Nonlinear Optics, Elsevier (2003),
Govind P. Agrawal, Nonlinear Fiber Optics, Elsevier (2007),
Anthony E. Siegman, Lasers, University Science Books (1986),
OrazioSvelto, Principles of Lasers, Springer (2010),
Miscellaneous Research Articles and Reviews.

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

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 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

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

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, Yogesh Simmhan

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.

Sashikumaar Ganesan

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 290 (AUG) 3:0

Modelling and Simulation

Statistical description of data, data-fitting methods, regression analysis, analysis of variance, goodness of fit. Probability and random processes, discrete and continuous distributions, Central Limit theorem, measure of randomness, Monte Carlo methods. Stochastic Processes and Markov Chains, Time Series Models. Modelling and simulation concepts,Discrete-event simulation: Event scheduling/Time advance algorithms verification and validation of simulation models. Continuous Simulation: Modelling with and Simulation of Stochastic Differential Equations

S.Raha

Banks, J., Carson, J.S., and Nelson, B., Discrete-Event System Simulation,
Second Edn, Prentice Hall of India, 1996.
Francois E. Cellier, Ernesto Kofman, Continuous System Simulation,
Springer, 2006, ISBN: 0387261028.
Peter E. Kloden, Eckhard Platen, Numerical Solutions of Stochastic
Differential Equations, Springer, Verlog, 1999.
Peter E. Kloden, Eckhard Platen, Henri Schurz, Numerical Solution of SDE
through Computer Experiments, Springer Verlog, 1994.

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
Mathew Jacob
Sathish Vadhiyar

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 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.

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.

K.Sekar
Debnath Pal

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 252 (JAN) 3:1

Introduction to Cloud Computing

Context: Taxonomy of parallel and distributed computing; Role of Cloud computing. Technology: Cloud Virtualization, Elastic computing; Infrastructure/Platform/Software as a Service (IaaS/PaaS/SaaS); Public/Private Clouds; Service oriented architectures. Design Patterns for Cloud Applications: Task/data parallel distributed algorithms; Task graphs and Map-Reduce model; Amdahl's law, data locality, speedup. Execution Models: Synchronous/ asynchronous execution patterns; Scale up/Scale out on VMs; Data marshalling/ unmarshalling; Asynchronous coordination; NoSQL Cloud storage. Evaluation: Load balancing; Performance metrics; Consistency, Availability and Partitioning (CAP theorem). Programming project using public Cloud infrastructure.

Yogesh Simmhan

Data Structures, Programming and Algorithm concepts. Programming experience required.

Distributed and Cloud Computing: From Parallel Processing to the Internet of Things, Kai Hwang, Jack Dongarra and Geoffrey Fox, Morgan Kaufmann, 2011
Current Literature

SE 255 (JAN) 3:1

System Virtualization

Course Description: Virtualization as a construct for resource sharing; Re-emergence of virtualization and it's importance for Cloud computing; System abstraction layers and modes of virtualization; Mechanisms for system virtualization – binary translation, emulation, para-virtualization and hardware virtualization; Virtualization using HAL layer - Exposing physical hardware through HAL (example of x86 architecture) from an OS perspective; System bootup process; Virtual Machine Monitor; Processor virtualization; Memory Virtualization; NIC virtualization; Disk virtualization; Graphics card virtualization; OS-level virtualization and the container model; OS resource abstractions and virtualization constructs(Linux Dockers example) ; Virtualization using APIs – JVM example.

J.Lakshmi

Basic course on operating systems and consent of the instructor. J. Smith, R. Nair, Virtual Machines: Versatile Platforms for Systems and Processess, Morgan Kaufman, 2005.
D. Bovet, M. Casti, Understanding the Linux Kernel, Third Edition, O'Reilly, 2005.
Wolfgang Mauerer, Linux Kernel Architecture, Wiley India, 2012.
D. Chisnall, The Definitive Guide to the Xen Hypervisor, Prentice Hall, 2007
R. Bryant, D. O'Hallaron, Computer Systems: A Programmer's Perspective (2nd Edition), Addison Wesley, 2010
Current literature.

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

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 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

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 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.

R. Venkatesh Babu
P.C.Mathias
Partha Talukdar

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.

Sathish Vadhiyar

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 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

SE 260 or E9 241 or consent from the Instructor.

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.

SK Nandy

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