# COURSE SYLLABUS

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| 1. | Title of the Course | High Dimensional Data Science |
| 2. | Course Number | CS 531 |
| 3. | Status of the Course | Programme Elective |
| 4. | Structure of Credits | L(3) - T(0) - P (0) - C [6 (Old), 3(New)] |
| 5. | Offered To | 3rd and 4th year CSE B. Tech., CSE M. Tech., Ph.D. |
| 6. | Prerequisite | Algorithm Design, Probability, Linear algebra, Calculus |
| 7. | **Course Objective:**<br>The objective is to understand the theoretical foundations of high dimensional data science. | |
| 8. | **Course Content:**<br>1. High Dimensional Space - The geometry of high dimension, properties of unit ball, Random projects and Johnson-Lindenstrauss Lemma, Separating gaussians<br>2. Singular Value Decomposition (SVD) - Introduction to SVD, best k-rank approximations, left singular vectors, power method for SVD, applications of SVD.<br>3. Compressed sensing | |
| 9. | **Text book(s):** None | |
| 10. | **Reference(s):**<br>1. Foundations of Data science by Blum, Hopcroft and Kannan<br>2. Understanding machine learning by Shai Shalev-Shwartz and Shai Ben-David | |

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| 1. | Title of the Course | Optimization: Theory and Algorithms |
| 2. | Course Number | CS 431 |
| 3. | Status of the Course | Program Elective |
| 4. | Structure of Credits | L(3) - T(0) - P (0) - C [6 (Old), 3(New)] |
| 5. | Offered To | CSE and MC B.Tech. 3rd, 4th-year/M.Tech./ Ph.D. |
| 6. | Prerequisite | Linear Algebra, Calculus, Programming experience (e.g MATLAB, Python) |
| 7. | **Course Objective:**<br>The objective is to be able to model problems as optimization problems, identify easy and hard instances of optimization problems, learn theory and techniques for solving linear and nonlinear programming problems. | |
| 8. | **Course Content:**<br>Modelling optimization problems, classes of problems- discrete, continuous, linear, quadratic, unconstrained and constrained<br>Unconstrained optimization – necessary and sufficient conditions, iterative algorithms: steepest descent, Newton's method, conjugate gradient<br>Convex Sets, Convex functions, Convex Optimization, Farkas Lemma<br>Linear Programming- applications in transportation, network flow, Simplex Method, Duality in LPs<br>Constrained Optimization – KKT conditions, Duality, Conditions for Strong Duality Applications in Machine Learning | |
| 9. | **Text book(s):**<br>1. David G. Luenberger and Yinyu Ye, Linear and Nonlinear Programming 3rd edition, Springer, ISBN: 978-0387745022<br>2. Edwin K.P. Chong and Stanislaw H. Zak, An Introduction to Optimization, 2nd edition, Wiley-Interscience Series in Discrete Mathematics and Optimization, ISBN: 0-471-39126-3<br>3. Stephen Boyd and Lieven Vandenberghe, Convex Optimization, Cambridge University Press, ISBN: 0-521-83378-7 | |
| 10. | **Reference(s):** Jorge Nocedal and Stephen Wright, Numerical Optimization, 2nd edition, Springer, ISBN: 978-0-387-30303-1<br>R. Fletcher, Practical Methods of Optimization, Wiley, ISBN: 978-0471494638<br>Bertsimas and Tsitsikilis, Introduction to Linear Optimization, Athena Scientific, ISBN: 978-1886529199 | |

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|---|---|---|
| 1. | Title of the Course | Computer Graphics using OpenGL |
| 2. | Course Number | CS 440 |
| 3. | Status of the Course | Institute Elective |
| 4. | Structure of Credits | L(3) - T(0) - P (0) - C [6 (Old), 3(New)] |
| 5. | Offered To | CS/EE/ME (3rd-year and 4th-year) |
| 6. | Prerequisite | CS 101 AND CS (113 OR 220 OR 400) |
| 7. | **Course Objective:** This is an introductory course on Computer Graphics. It is an open elective for CS and Non-CS students with exposure to Data Structures and Programming. Students will be graded based on Mid-Semester exam, Programming Assignments, a Mini-Project and an End-semester examination. There will be no separate lab associated with the course. | |
| 8. | **Course Content:**<br>Introduction to Computer Graphics: Graphics Application and Software, Input Devices, Vector and Raster Refresh Displays, LCD displays.<br>Two-Dimensional Transformations: Homogeneous Coordinates, Matrices and Point transformation Translation, Scaling and Rotation<br>Three-Dimensional Transformations: Rotation about an Arbitrary Axis in Space, Perspective Views, Camera models, Orthographic Projections, Axonometric Projections, Oblique Projections, View volumes for projections.<br>Viewing in 3D: 3D viewing pipeline, Specifying an Arbitrary 3D View, Combined transformation matrices for projections and viewing, Coordinate Systems and matrices, camera model and viewing frustrum.<br>Clipping, filling and Scan conversion: Scan conversion of lines, circles Filling polygons edge data structure, Line Clipping algorithms, Clipping Polygons, problem with multiple components. Problems of Aliasing.<br>Graphics Programming using OpenGL: OpenGL, features in OpenGL, OpenGL operations, Abstractions in OpenGL – GL, GLU & GLUT, 3D viewing pipeline, viewing matrix specifications, a few examples and demos of OpenGL programs.<br>Solid Modelling: Representing Solids, Regularized Boolean Set Operations, Sweep Representations, Spatial-Partitioning Representations - Octree representation, B-Reps, Constructive Solid Geometry<br>Visible-Surface Determination: Techniques for efficient Visible-Surface Algorithms, Categories of algorithms, Back face removal, The z-Buffer Algorithm, Scan-line method, Painter's algorithms, Ray Tracing, BSP trees<br>Illumination and Shading: Reflectance properties of surfaces, Ambient, Specular and Diffuse reflections, Atmospheric attenuation, Phong's model, Gouraud shading<br>Plane Curves and Surfaces: Curve Representation, Nonparametric Curves, Parametric Curves, Cubic Splines, Bezier Curves, B-spline Curves, Quadric Surfaces. Bezier Surfaces. | |
| 9. | **Text book(s):**<br>1. D. Hearn and M. Pauline Baker, Computer Graphics with OpenGL, 4th Ed. Pearson Education<br>**2.** J. D. Foley, A. Van Dam, S. K. Feiner and J. F. Hughes, Computer Graphics - Principles, 3rd Ed. Pearson Education | |
| 10. | **Reference(s):**<br>1. Peter Shirley, Fundamentals of Computer Graphics, 4th Edition, CRC Press<br>2. Sumanta Guha, Computer Graphics Through OpenGL, 2nd Edition, CRC Press | |

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| | 3. D. F. Rogers and J. A. Adams, Mathematical Elements for Computer Graphics, 2nd Edition, McGraw-Hill International Edition, 1990.<br>**4.** F. S. Hill Jr., Computer Graphics using OpenGL, Pearson Education, 2003 |

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|---|---|---|
| 1. | Title of the Course | Foundations of Digital Transformation |
| 2. | Course Number | CS 441 |
| 3. | Status of the Course | Institute Elective |
| 4. | Structure of Credits | L(2) - T(0) - P (0) - C [4 (Old), 2(New)] |
| 5. | Offered To | CS/EE/ME (4th-year); M. Tech. |
| 6. | Prerequisite | CS 101 |
| 7. | **Course Objective:** Businesses around the globe are undergoing major transformations as their business model, business processes, underneath systems and platforms are continuously aligning with new and upcoming digital technologies. In this course we will study the basics of Digital Transformation, threats to existing businesses, and ways of transforming existing businesses using digital technologies. We will also study, in brief, the concept and applications of various digital technologies.<br>The course will be useful for graduating BTech and MTech students. The course will help them in understanding and applying digital technologies, not only for marginal productivity gains, but as an enabler for innovation and new business ideas. | |
| 8. | Course Content:<br>Module I: What is Digital Transformation? [2 hours]<br>In this module we study how technologies change businesses. We will look at the exponential rate at which technologies are advancing and how this creates opportunities for existing and new businesses. We will also learn about how everything is becoming digital and its impact on our lives and businesses.<br>Module II: What is disruptive Innovation? [2 hours]<br>In this module, we will study how new technologies (eg. Cloud) can threaten established companies. We will look at supply and demand side disruptions.<br>Module III: The Internet, Web, Cloud, AI and Machine Learning [4 hours]<br>We will study how the Internet and Related technologies can be used for transforming businesses. We will start with basic concepts of the Internet and then we will study Web and Cloud Technologies.<br>Module IV: Digital Transformation Technologies [3 hours]<br>We will briefly look at concepts, and disruptive applications of existing and new digital technologies.<br>Module V: Managing Disruptive Changes [2 hours]<br>We will learn how companies can respond to disruptive changes and why it is so hard for companies to execute these theories. We will also study how development of platforms may help organizations in the digital journey.<br>Module VI: Digital Transformation Case Studies [6 hours]<br>We will invite an expert from Industry to present a few case studies in digital transformation.<br><br>Module VII: Digital Transformation project Presentation [4 hrs]<br>A team of 3-4 students will study a business happening in Indian cities or villages. Team will come up with ideas on how to digitally transform the business, if possible. Students will present the idea in the class within 10 mins time period. | |

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| | Module VIII: Management of Enterprise orientation towards Digital Technologies [4 hours] : Culture, Process Transformation, Alignment, Strategic Focus etc. |
| 9. | **Text book(s):**<br>1. George Westerman, Leading Digital: Turning Technology into Business Transformation<br>2. Ashish Pachory, Aligned to Win, Zorba books<br>3. David L Rogers, The Digital Transformation Playbook, Columbia Business School<br>**4.** Dominic M Mazzone, Digital or Death: Digital Transformation - The Only Choice for Business to Survive, Smash, and Conquer |
| 10. | **Reference(s):**<br>1. Digital Transformation: A Roadmap For Billion-Dollar Organizations, by CapGemini<br>2. Aligning Technology with Business for Digital Transformation, Ashish Pachory, BEP Publication<br>3. Born to be digital: How leading CIOs are preparing for a digital transformation, by EY<br>4. Digital transformation: Creating new business models where digital meets physical, by IBM<br>5.Clayton M. Christensen, Michael Raynor, Rory McDonald. "What is Disruptive Innovation?" Clayton M. Christensen, Michael Raynor, Rory McDonald, Harvard Business Review, December 2015. (HBS)<br>6. Joshua Gans, "The Other Disruption," Harvard Business Review, March 2016. (HBS)<br>7. G. Parker, Sangeet Paul Choudary, Platforms, Pipelines, and the New Rules of Strategy," Marshall W. Van Alstyne, Geoffrey, Harvard Business Review, April 2016. (HBS) |

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|---|---|---|
| 1. | Title of the Course | Econometric Data Science |
| 2. | Course Number | HS421 |
| 3. | Status of the Course | Core / Programme Elective / Institute Elective |
| 4. | Structure of Credits | L(3) - T(0) - P (0) - C [6 (Old), 3(New)] |
| 5. | Offered To | B.Tech 2nd & 4th year students |
| 6. | Prerequisite | ----- |
| 7. | **Course Objective:**<br>The course introduces the quantitative techniques used in business, finance, economics, government, consulting and many other fields. The course introduces the econometric models and techniques used for data description, modeling, forecasting, policy analysis, and strategic planning.<br>The topics covered in this course include: Regressions under ideal conditions. Misspecification and Model selection, Non-linearity, heteroscedasticity, Group heterogeneity, and indicator variables, Limited dependent variables, Timeseries- trend-cycle decomposition, stationarity, ARMA models, VAR, and dynamic heteroscedasticity. Forecasting methods and evaluations | |
| 8. | **Course Content:** | |
| 9. | **Text book(s):**<br>1. Diebold, F.X. , *Econometric Data Science*, Department of Economics, University of Pennsylvania,2019. http://www.ssc.upenn.edu/~fdiebold/Textbooks.html.<br>2. Jeffrey M. Wooldridge, Introductory Econometrics: A Modern Approach (5th, 4th or 3rd Edition), Cengage Learning, 2008.<br>3. James H. Stock, Mark W. Watson, Introduction to Econometrics, Pearson/Addison Wesley, 2008.<br>4. Diebold, F.X. , Forecasting, Department of Economics, University of Pennsylvania 2019, | |
| 10. | **Reference(s): --------** | |

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|---|---|---|
| 1. | Title of the Course | Numerical Simulation and its applications |
| 2. | Course Number | IE 601 |
| 3. | Status of the Course | Institute Elective |
| 4. | Structure of Credits | L(2) - T(1) - P (0) - C [6 (Old), 3(New)] |
| 5. | Offered To | B. Tech. 2nd year onward (CSE, ME, EE, MnC)/ M. Tech./ Ph. D. |
| 6. | Prerequisite | None |
| 7. | **Course Objective:** The course will offer the students a platform to learn how to solve physical problems through the advanced scientific/numerical simulation techniques using Fortran. In addition, it will include tutorials with few selective problems to provide the students a hands-on experience of writing their own code to build up and solve different model systems. | |
| 8. | **Course Content:** Fortran Language: Introduction to Fortran; Simple Fortran programs; numerical constants and variables; arithmetic expressions; logical expressions; functions and subroutines; arrays; elementary format specifications; string of characters; program examples; processing files; pointer data type; modules; miscellaneous features of Fortran.<br>Simulation: Overview of Monte-Carlo (MC), Brownian Dynamics (BD), Molecular Dynamics (MD) simulations etc. Implementations of Fortran language to various computer simulation methods. | |
| 9. | **Text book(s):**<br>1. V. Rajaraman, Computer Programming in Fortran 90 and 95, PHI Learning Private Limited (2013).<br>2. Daan Frenkel and Berend Smit, Understanding Molecular Simulation: From Algorithm to Applicatio Academic Press (2002). | |
| 10. | **Reference(s):** 1. C. Xavier, Fortran 77 and Numerical Methods, New Age International Private Limited (1994). | |

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|---|---|---|
| 1. | Title of the Course | Introduction to Quantitative Finance |
| 2. | Course Number | IE 602 |
| 3. | Status of the Course | Institute Elective |
| 4. | Structure of Credits | L(2) - T(0) - P (0) - C [2 (Old), 1(New)] |
| 5. | Offered To | 2nd, 3rd & 4th year BTech's, MTech's, PhD's |
| 6. | Prerequisite | Mathematical inclination |
| 7. | **Course Objective:** Derivative market in the finance world is estimated at $ 1 Quadrillion on the high end, almost 10 times the total of worlds Gross Domestic Product by some analysts. In this course the student will get an introduction to the mathematics involved in construction and pricing of these derivative instruments. | |
| 8. | **Course Content:** Products and Markets: Equities, Commodities, Exchange Rates, Forwards and Futures, Derivatives, The Binomial Model, The Random Behavior of Assets, Elementary Stochastic Calculus, The Black–Scholes Model, Partial Differential Equations, The Black–Scholes Formulae and the 'Greeks', Overview of Volatility Modeling, How to Delta Hedge, An Introduction to Exotic and Path-dependent Options, Multi-asset Options, Barrier Options, Fixed-income Products and Analysis: Yield, Duration and Convexity, Yield Curve Fitting, Interest Rate Derivatives. | |
| 9. | **Text book(s):**<br>Wilmott, P. (2007). Paul Wilmott introduces quantitative finance. John Wiley & Sons. | |
| 10. | **Reference(s):**<br><br>McMillan, L. G. (2002). Options as a strategic investment. Penguin. Xinfeng Z , (2020), A Practical Guide To Quantitative Finance Interviews, lulu.com<br><br>Hull, J. (2009). Options, futures and other derivatives/John C. Hull. Upper Saddle River, NJ: Prentice Hall. | |

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|---|---|---|
| 1. | Title of the Course | Analytical Techniques Laboratory |
| 2. | Course Number | CHL802 |
| 3. | Status of the Course | Core / Programme Elective / Institute Elective |
| 4. | Structure of Credits | L(2) - T(0) - P (4) - C [8 (Old), 4(New)] |
| 5. | Offered To | BTech (6 th and 8 th sem), MTech (2 nd and 4 th sem), PhD and compulsory for PhD students enrolled for Chemistry program. |
| 6. | Prerequisite | Nil |
| 7. | **Course Objective:** Hand-on experiments using sophisticated analytical instruments. The course will allow<br>students to develop additional analytical skills in multidisciplinary fields besides their core interests | |
| 8. | **Course Content:**<br>Safety methods in research laboratories<br>□ Modern instrumentation and operation of analytical instruments<br>□ Database search for crystals/chemicals/materials<br>□ Data handling and interpretation of selected techniques.<br>□ Computational techniques<br>Details of different experiments:<br>□ UV-Vis spectrophotometer: To understand the role of pH<br>□ Fluorescence spectrometer: To understand the role viscosity<br>□ IR spectrophotometers: Estimate the caffeine amount in a coffee sachet.<br>□ HPLC-MS: Development of a method for identification and estimation of a single component in a<br>mixture.<br>□ Gas chromatography (GC): Forensic investigation of an arson crime<br>□ TGA: Understand the role of crystal-water<br>□ DSC: Metastable state of a crystal<br>□ DLS: Particle size estimation in water<br>□ Cyclic Voltammetry: Understand the electrochemistry<br>□ Simulation of a small molecule using open source software | |
| 9. | **Text book(s):** | |
| 10. | **Reference(s):** 1. Fundamentals of Analytical Chemistry by Stanley Crouch, Douglas Skoog, F.<br>Holler, Doland West.<br>2. Principle of Instrumental Analysis by D. A. Skoog | |

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|---|---|---|
| 1. | Title of the Course | Aerosol Technology |
| 2. | Course Number | ME604 |
| 3. | Status of the Course | Core / Programme Elective / Institute Elective |
| 4. | Structure of Credits | L(3) - T(0) - P (0) - C [6 (Old), 3(New)] |
| 5. | Offered To | BTech (4th and 8th sem), MTech (2 nd and 4 th sem), PhD |
| 6. | Prerequisite | NIL |
| 7. | **Course Objective: NIL** | |
| 8. | **Course Content:** Particle Size, shape, concentrations. Size distributions. Moments. Weighted distributions.<br>Particle motion, Stokes' law, settling velocity.<br>Langevin Dynamics, Brownian Dynamics.<br>Formation, growth and coagulation of nanoparticles, condensation and nucleation, coagulation kernels.<br>Non-spherical nanoparticles, statistical fractals and fractal structure, aggregation of non-spherical nanoparticles.<br>Filtration, deposition mechanisms, respiratory deposition.<br>Common measurement techniques, mobility-based measurements, equivalent diameters, characterization of non-spherical nanoparticles.<br>Aerosols and radiative properties, effects on air pollution. | |
| 9. | **Text book(s):** | |
| 10. | **Reference(s):** 1) Hinds, W. C., "Aerosol technology: properties, behavior, and measurement of airborne particles", John Wiley & Sons, United States. 2nd edition.<br>2) Friedlander, S.K., "Smoke, Dust and Haze: Fundamentals of aerosol dynamics", Oxford University Press, United Kingdom. | |

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|---|---|---|
| 1. | Title of the Course | Advanced Convective Heat Transfer |
| 2. | Course Number | ME 602 |
| 3. | Status of the Course | Core / Programme Elective |
| 4. | Structure of Credits | L(3) - T(0) - P (0) - C [6 (Old), 3(New)] |
| 5. | Offered To | UG/PG/PhD open elective |
| 6. | Prerequisite | - |
| 7. | **Course Objective: ---** | |
| 8. | **Course Content:** Introduction to Convective Heat Transfer, governing equations: momentum,<br>energy conservation equation. External forced convection: scaling analysis, similarity solution and integral solution of momentum and energy. Suction and Blowing. Falkner-Skan equation. Internal forced convection: developing flow, hydrodynamically fully developed flow, Mean temperature, flow with uniform heat flux, flow with uniform wall temperature, heat transfer.<br>Laminar slug flow, power law fluids. External natural convection: scaling analysis, similarity and integral solution, with uniform heat flux, with uniform wall temperature. Mixed Convection.<br>Internal Natural Convection: Scaling analysis, heat transfer regimes, partially divided enclosure, inclined enclosures. Introduction to Turbulence: Reynold's averaged Navier-Stokes equation, Turbulent boundary layer, viscous sublayer, fully turbulent sublayer, heat transfer in turbulent boundary layer. Turbulent internal flow. Turbulence modeling: k-epsilon, K-omega, Reynolds stress equation model (RSM) and other models. Convection with change of phase: boiling, condensation. Brief introduction to mass transfer. | |
| 9. | **Text book(s):** 1. "Convection Heat Transfer", Adrian Bejan, Wiley, 4th Edition, 2013. ISBN 78-0-470-90037-6.<br>2. "Convective Heat Transfer", Louis C Burmeister, Wiley, 2nd Edition, 1993. ISBN 978-0471577096. | |
| 10. | **Reference(s): --------** | |

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|---|---|---|
| 1. | Title of the Course | Computational Heat and fluid flow |
| 2. | Course Number | ME 605 |
| 3. | Status of the Course | Programme Elective |
| 4. | Structure of Credits | L(3) - T(0) - P (0) - C [6 (Old), 3(New)] |
| 5. | Offered To | UG/ PG/PhD |
| 6. | Prerequisite | Fluid Mechanics (ME219) or any related course |
| 7. | **Course Objective: ---** | |
| 8. | Course Content: 1. Preliminaries: Continuum approximation, governing equations for fluid flow and heat transfer, introduction to computational fluid dynamics<br>2. Discretization methods: Finite difference method: Taylor series, backward, forward and central differences, truncation error, discretization of 1D diffusion equation, TDMA and Gauss-Seidel method<br>Finite volume method: Control volume approach, basic rules<br>3. Finite volume method for diffusion problems: Discretization and solution of 1D diffusion equations, boundary conditions, unsteady 1D diffusion equation, explicit, Crank-Nicolson and implicit schemes, 2D and 3D situations<br>4. Finite volume method for convection-diffusion equations: Failure of central schemes,properties of discretization schemes, upwind, QUICK, hybrid and power law schemes, 2D and 3D discretized equations<br>5. Finite volume method for Navier-Stokes equations: Navier-Stokes equations, related difficulties, staggered grid, SIMPLE, SIMPLER, SIMPLEC and PISO, fractional step method urse Content: | |
| 9. | Text book(s):<br>. An Introduction to Computational Fluid Dynamics: The Finite Volume Method, H. Versteeg, W. Malalasekera, 2nd edition, Prentice Hall, 2007<br>. Numerical Heat Transfer and Fluid Flow, 1st edition, S. V. Patankar, CRC Press, 1980<br>. Computational Fluid Dynamics: The Basics with Applications, J. D. Anderson, McGraw Hill Education, 2017<br>. Computational Methods for Fluid Dynamics, J.H. Ferziger, M. Peric, 3rd edition, Springer, 2002 | |
| 10. | **Reference(s): --------** | |

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|---|---|---|
| 1. | Title of the Course | Finite Element Method |
| 2. | Course Number | ME 615 |
| 3. | Status of the Course | Core / Programme Elective / Institute Elective |
| 4. | Structure of Credits | L(3) - T(0) - P (0) - C [6 (Old), 3(New)] |
| 5. | Offered To | UG/PG/PhD |
| 6. | Prerequisite | |
| 7. | **Course Objective: -------** | |
| 8. | **Course Content:**<br>Fundamentals of Finite Element Formulation:<br>Method of weighted residual; Weak formulation; Piecewise continuous trial function; Variational method (Principle of stationary functional); Rayleigh-Ritz method; Rayleigh-Ritz finiteelement method. One-Dimensional Finite Element Analysis:<br>Finite element formulation for 1-D problems; Linear bar element; Quadratic bar element; Structural analysis of trusses using bar elements; Beam element; Structural analysis of frames; Temperature effects.<br>Two-Dimensional Finite Element Analysis:<br>2-D elementsfor heat transfer problems: (1) 3-noded triangular element, (2) 4-noded rectangular element and (3) 6-noded triangular element; 2-D stress analysis formulation; Natural coordinates and Coordinate transformations; 2-D elements for structural mechanics:<br>(1) 3-noded triangular element or constant strain element (CST), (2) 4-noded quadrilateral element, (3) 6-noded triangular element and (4) 8-noded quadrilateral element; Numerical integration; Axisymmetric element.<br>Dynamic Analysis using Finite Element Method:<br>Equation of motion based on weak form; Equation of motion using Lagrange's approach; Consistent and lumped mass matrices; Finite element formulation for vibration problem. | |
| 9. | **Text book(s):**<br>1. Introduction to Finite Elementsin Engineering BY T. R. CHANDRUPATLA AND<br>A. D. BELEGUNDU; PEARSON EDUCATION INDIA; 2015.<br>2. A First Course in Finite Elements BY J. Fish AND T. BELYTSCHKo; JOHN WILEY & SON 2007.<br>3. Textbook of Finite Element Analysis BY P. SESHU; PRENTICE-HALL of INDIA PVT. LT 2004.<br>4. An Introduction to the Finite Element Method BY J. N. REDDy; MCGRAW HILL EDUCATION; 2017. | |
| 10. | **Reference(s): --------** | |

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|---|---|---|
| 1. | Title of the Course | Gas Dynamics |
| 2. | Course Number | ME 616 |
| 3. | Status of the Course | Core / Programme Elective / Institute Elective |
| 4. | Structure of Credits | L(3) - T(0) - P (0) - C [6 (Old), 3(New)] |
| 5. | Offered To | UG/PG/ PhD course |
| 6. | Prerequisite | Introductory course in Fluid dynamics and thermodynamics |
| 7. | **Course Objective: -------** | |
| 8. | **Course Content:** Conservation laws: Introduction to basic concepts in fluid mechanics, Conservation of mass, momentum, Euler equation, Mach number, Speed of sound<br>Review of thermodynamics: Ideal gases, steady isentropic flow, stagnation properties, Energy, Entropy equation<br>One dimensional flow: Variable area flow, Choked flow, Subsonic and supersonic nozzles, Flow with friction, Fanno line, Flow with Heat Addition, Rayleigh Line<br>Shock waves: Normal shock waves, Conservation relations, Hugoniot relation, Moving shocks, strong and weak shocks, Oblique shocks<br>Two-dimensional flow: Steady 2D Supersonic Flows: Mach Waves, Prandtl-Meyer Function, Expansion Fans, Method of characteristics<br>One dimensional unsteady flow: Finite Amplitude Waves, Characteristics, Riemann Invariants, Piston problems, boundary interactions, shock tubes, Viscous effects | |
| 9. | **Text book(s):**<br>**. Liepmann, H.W and Roshko. .A. (2002) Elements of Gas dynamics, Dover Publications**<br>**. Shapiro A.H. The dynamics and thermodynamics of Compressible flow, Dover Publications**<br>**. Anderson J. (1977) Modern Compressible flow: with historical perspective, McGraw Hill Education** | |
| 10. | **Reference(s): --------** | |

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|---|---|---|
| 1. | Title of the Course | Mechanics of Composite Materials |
| 2. | Course Number | ME 617 |
| 3. | Status of the Course | Core / Programme Elective / Institute Elective |
| 4. | Structure of Credits | L(3) - T(0) - P (0) - C [6 (Old), 3(New)] |
| 5. | Offered To | UG/PG/PhD |
| 6. | Prerequisite | ME201 Mechanics of Materials or any course on solid mechanics |
| 7. | **Course Objective: -------** | |
| 8. | **Course Content:** Definition, Classification of composites, Constituent materials – fibers, matrices, applications of composites.<br>Fabrication techniques: Manufacturing of thermoset and thermoplastic composites, Other manufacturing methods, Properties of constituents and composites.<br>Micromechanics of composites: Volume fraction and weight fraction, prediction of properties from micromechanics, Rule of mixtures.<br>Analysis of Lamina: Anisotropic elasticity, Properties of lamina, Stress-strain relations of lamina, Transformations of elastic constants.<br>Analysis of laminates: Laminate configurations and definitions, Assumptions, Classical laminate theory (CLT), Higher order shear deformation theory, Hygrothermoelastic laminate theory.<br>Failure of composites: Introduction to failure concepts, Micromechanics of failure in unidirectional laminates, Different failure theories | |
| 9. | **Text book(s):**<br>Analysis and Performance of Fibre Composites, BD Agarwal and LJ Broutman Mechanics of Composite Materials and Structures, Madhujit Mukhopadhyay Mechanics of Fibrous Composites, CT Herakovich<br>Mechanics of Composite Materials, Jones, R. M., Mc-Graw Hill Mechanics of Composite Materials, RM Christensen<br>Materials provided by Instructor | |
| 10. | **Reference(s): --------** | |

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|---|---|---|
| 1. | Title of the Course | Microscale Transport Phenomena and Microfluidics |
| 2. | Course Number | ME 619 |
| 3. | Status of the Course | Core / Programme Elective / Institute Elective |
| 4. | Structure of Credits | L(3) - T(0) - P (0) - C [6 (Old), 3(New)] |
| 5. | Offered To | UG, PG/PhD |
| 6. | Prerequisite | Fluid Mechanics, Basic Physics and Chemistry. Reference |
| 7. | **Course Objective: -------** | |
| 8. | **Course Content:** Introduction and Applications of micro scale fluid flow. Basic concepts in microfluidics: Scaling laws, Fluids and fields. Basic governing equations and basic flow solutions.<br>Continuum assumption and limits of linear transport properties.<br>Microscale transport equations, Pressure-driven Microflows, unsteady flows, Stokes Drag, Lubircation Theory, Continuum flow (with slip), Surface Tension Driven Flows, Thin Film Dynamics, free molecular flow.<br>Electrokinetics: electric double layer, Electro-osmotic flow, Capillary filling, passive valves, electro-wetting, electrophoresis, isoelectric focusing, dielectrophoresis etc.<br>Biomicrofluidics , Flow of Non-newtonian Fluids.<br>Micro-fabrication - photolithography, wet and dry etching, molding, casting, assembly etc. Pumps, valves, mixers, sensors. Concepts and examples of micro heat pipes, droplet based microfluidics, Lab on a CD. Lab Demo. | |
| 9. | **Text book(s):**<br>. Theoretical Microfluidics. Henrik Bruus, Oxford University Press. 2008. ISBN 978–0–19–923508–7.<br>. Microfluidics and Microfabrication. Editor Suman Chakraborty. Springer 2010. ISBN: 978- 1-44-191542-9<br>. Intermolecular and Surface Forces. Jacob N. Israelachvili, 3rd edition. Academic Press 2011.ISBN 978-0-12-391933-5.<br>. Microfluidics and Microscale Transport Processes. Suman Chakraborty, 1st Edition, CRC Press 2012. ISBN 978-1-43-989924-3 | |
| 10. | **Reference(s): --------** | |

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|---|---|---|
| 1. | Title of the Course | Continuum Mechanics |
| 2. | Course Number | ME 613 |
| 3. | Status of the Course | Core / Programme Elective / Institute Elective |
| 4. | Structure of Credits | L(3) - T(0) - P (0) - C [6 (Old), 3(New)] |
| 5. | Offered To | UG/PG/PhD |
| 6. | Prerequisite | NIL |
| 7. | **Course Objective: -------** | |
| 8. | **Course Content:**<br>Introduction and essential mathematics: Concept of continuum, Vectors and Tensors, Indicial notation, Coordinate transformations, Principal values and directions, Invariants of a second-order tensor, Dyadic product, Vector and tensor calculus.<br>Kinematics of deformation: Configurations of a body, displacement, velocity, acceleration, Lagrangian and Eulerian descriptions of ow field. Deformation gradient tensor, Finite strain tensor, Infinitesimal strain, Principal strains, Dilatation, Compatibility equations. Velocity gradient tensor, Rate of deformation tensor, Spin tensor. Example of some simple flows.<br>Stress and conservation laws: Surface traction, Cauchy's stress principle, Symmetry of stress tensor, Principal stresses, Stress invariants, Stress deviator tensor. Some simple states of stress: uniform extension, pure bending, pure torsion, etc. Conservation laws: mass, linear momentum, angular momentum, and energy.<br>Constitutive law and boundary value problems: Frame indifference, Material symmetry. Constitutive equations for general linear elastic solid: isotropic, orthotropic and transversely isotropic solid.<br>Constitutive equation for Newtonian fluid. Incompressibility. Solution of some boundary value problems of solids and fluids. | |
| 9. | **Text book(s):**<br>1. Continuum Mechanics, A. J. M. Spencer. Dover Publications, New York.<br>2. Continuum Mechanics, P. Chadwick. Dover Publications.<br>3. Continuum Mechanics for Engineers, G. Thomas Mase and George E. Mase. CRC Press.<br>4. Continuum Mechanics: Foundations and Applications of Mechanics (Vol. 1), C. S. Jog. Cambridge University Press.<br>5. Elasticity: Theory, Applications and Numerics, Martin H. Sadd. Elsevier.<br>6. Theory of Elasticity, S. Timoshenko and J. N. Goodier. McGraw Hill Education. | |
| 10. | **Reference(s): --------** | |

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|---|---|---|
| 1. | Title of the Course | System Identification and Adaptive Control |
| 2. | Course Number | EE 602 |
| 3. | Status of the Course | Core / Programme Elective / Institute Elective |
| 4. | Structure of Credits | L(3) - T(0) - P (0) - C [6 (Old), 3(New)] |
| 5. | Offered To | UG/PG/PhD |
| 6. | Prerequisite | NIL |
| 7. | **Course Objective: -------** | |
| 8. | **Course Content:** Introduction and overview of Systems Identification, Adaptive Control and applications. Parameter Estimation: Least Square, Generalized and Recursive Least Square, Estimator properties including error bounds and convergence, MES, ML and MAP estimators, Nonlinear Least Squares. Model Structures and Predictors. Recursive Identification of Linear dynamic systems: RLS, ELS, IV, RML, Stochastic Approximation, Extended Kalman Filter, generalized prediction error framework and its application to ARMA and state models, convergence analysis, Time varying parameters. Nonlinear System Identification. Adaptive schemes. Adaptive control theory. Applications. Situations when constant Gain feedback is insufficient. Robust control. The adaptive control problem. The model following problem. MRAS based on stability theory. Model following when the full state is measurable. Direct MRAS for general linear systems. Prior knowledge in MRAS. MRAS for partially known systems. Use of robust estimation methods in MRAS. The basic idea. Indirect self-tuning regulators. Direct Self-tuning regulators. Linear Quadratic STR. Adaptive Predictive control. Prior knowledge in STR. Linear-in-theparameters model. Least squares estimation. Experimental conditions. Recursive estimators. Extended least squares. Robust estimation methods (dead zone, projection). Implementation issues. Nonlinear System Identification Techniques | |
| 9. | **Text book(s):**<br>1. K.J. Astrom and B. Wittenmark, Adaptive Control, Pearson,2006<br>2. L. Ljung, System Identification Theory for the user, Prentice-Hall, 2007<br>3. K.S. Narendra and A.M. Annaswamy, Stable Adaptive Systems,, Prentice-Hall, 1989.<br>4. Miroslav Krsti, Ioannis Kanellakopoulos, and Petar V. Kokotovic, Nonlinear and Adaptive<br>Control Design, Wiley-Interscience, 1995 | |
| 10. | **Reference(s): --------** | |

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|---|---|---|
| 1. | Title of the Course | Insulation in Power Apparatus and System |
| 2. | Course Number | EE 612 |
| 3. | Status of the Course | Core / Programme Elective / Institute Elective |
| 4. | Structure of Credits | L(3) - T(0) - P (0) - C [6 (Old), 3(New)] |
| 5. | Offered To | UG/PG/PhD |
| 6. | Prerequisite | NIL |
| 7. | **Course Objective: -------** | |
| 8. | **Course Content:** Introduction to HV engineering course and challenges & opportunities in electric power equipment industry; Insulation engineering: Insulation materials, Stresses on power apparatus insulation & insulation systems of various power apparatus; Fundamentals of Insulation Breakdown: Electrical breakdown in gases, liquid and solid dielectrics; Stress Control: Principles of stress control, Stress distribution in multiple dielectrics, Stress calculation; Generation of high voltages in laboratory: Generation of High voltage AC by cascading and series resonant system, High DC voltages, Multistage impulse generator circuits, Impulse current generator; Measurement of High Voltages : AC voltage, DC voltage, Impulse voltages; Non-Destructive Insulation Assessment: Schering bridge, Ampere turns bridge, Standard Capacitor, Partial discharge; Testing of Power apparatus: Non-destructive tests to check integrity of insulation of on various power apparatus, Impulse test of transformers. | |
| 9. | **Text book(s):**<br>1. Kuffel E., Zaengl W.S. and Kuffel J., High Voltage Engineering Fundamentals, ButterworthHeineman press, Oxford, 2000.<br>2. M S Naidu & V Kamaraju, High Voltage Engineering, Tata McGraw Hill, 2004 | |
| 10. | **Reference(s):** 1. Naser E, Fundamentals and Gaseous Ionization and Plasma Electronics, John Wiley & Sons, Inc., New York, 1971. 2. A.von Hippel and A. S. Labounsky, Dielectric Materials and Applications, Artech House, Boston, 1995. | |

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|---|---|---|
| 1. | Title of the Course | Power Electronic Converters |
| 2. | Course Number | EE 613 |
| 3. | Status of the Course | Core / Programme Elective / Institute Elective |
| 4. | Structure of Credits | L(3) - T(0) - P (0) - C [6 (Old), 3(New)] |
| 5. | Offered To | UG/PG/PhD |
| 6. | Prerequisite | NIL |
| 7. | **Course Objective: -----** | |
| 8. | **Course Content:** Power semiconductor devices, Uncontrolled and controlled AC-DC converters, AC-AC converters, Non-isolated and isolated DC-DC converters, DC-AC converters, Modulation techniques, Harmonic Analysis, Resonant Converters, Multilevel converters, Design aspects of Power electronic converters, Gate drive circuits and Protection | |
| 9. | **Text book(s):**<br>N. Mohan, T. M. Undeland, and W. P. Robbins, Power Electronics: Converters, Applications, and Design, John Wiley & Sons, 3rd ed., 2007. 2. M. H. Rashid, Power Electronics: Circuits, Devices and Applications, Pearson Education India, 4th ed., 2017 3. R. W. Erickson, D. Maksimovic, Fundamentals of Power Electronics, Kluwer Academic Publishers, 2nd ed., 2001. 4. G K Dubey, S R Doradla, A Joshi, and R M K Sinha, Thyristorized Power Controllers, New Age International, 2nd ed., 2012. 5. D. G. Holmes and T. A. Lipo, Pulse Width Modulation for Power Converters: Principles and Practice, John Wiley & Sons, 2003. | |
| 10. | **Reference(s): --------** | |

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|---|---|---|
| 1. | Title of the Course | Estimation and Filtering |
| 2. | Course Number | EE623 |
| 3. | Status of the Course | Programme Elective |
| 4. | Structure of Credits | L(3) - T(0) - P (0) - C [6 (Old), 3(New)] |
| 5. | Offered To | PG/PhD/UG |
| 6. | Prerequisite | - |
| 7. | **Course Objective:**<br>The objective of the course is to introduce the fundamentals of estimation theory and filtering concepts. In particular, the course deals with application to system modeling, estimation and adaptive signal processing applications in various applications like, noise cancellation, fault detection, harmonic analysis, selective filtering and radar applications. | |
| 8. | **Course Content:**<br>Review of background – Gaussian random variables, vectors, co variance and transformation of Gaussian random vectors. Discrete time Fourier transform and Z Transform. Linear Algebra – Matrices, Norms, Trace, Eigen values and vectors, Linear transformation, Quadratic forms.<br>Signal Modeling – Least Squares method, Pade Approximation, Prony's method, Shank's method, Pole zero modeling, All pole modeling, Filter design examples. Statistical signal models – AR, MA, ARMA models. Optimum Filters – Wiener filter, Smoothing, filtering, prediction and deconvolution applications. FIR and IIR Wiener Filters, Causal and Non causal. Discrete Kalman Filter.<br>Estimation by filtering, Optimal estimation, linear estimation, Minimum variance unbiased estimation, Cramer Rao Lower bound (CRLB), Fisher information, Neyman Fisher factorization, Maximum Likelihood Estimation. Best Linear unbiased estimation, linear models. Bayesian Estimation. | |
| 9. | **Text book(s):**<br>M. Hayes, Statistical Signal Processing and Modeling, Wiley Publisher, 978-0471594314<br>S.M. Kay, Fundamentals of Statistical Signal Processing – Volume I, Estimation Theory, Prentice Hall Publishers, 978-0133457117 | |
| 10. | **Reference(s):**<br>Ali H Sayed, Adaptive Filters, Wiley Publishers, 978-0470253885<br>Manolakis, Statistical and Adaptive Signal Processing, McGraw-Hill, 978-0070400511 | |

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|---|---|---|
| 1. | Title of the Course | Circuits and Systems for Communication |
| 2. | Course Number | EE634 |
| 3. | Status of the Course | Programme Elective |
| 4. | Structure of Credits | L(3) - T(0) - P (0) - C [6 (Old), 3(New)] |
| 5. | Offered To | PhD/UG |
| 6. | Prerequisite | EE632 Analog Integrate Circuit Design |
| 7. | **Course Objective:**<br>This course focuses on the circuit and system level implementation details of communication systems, particularly that of wireless and broadband communication systems. | |
| 8. | **Course Content:**<br>Overview of communication systems.<br>Wireless systems: Overview of wireless communication systems, Design considerations: nonlinearity, noise, sensitivity, dynamic range etc., Review of modulation techniques, Transceivers: Building blocks such as low noise amplifiers, mixers, voltage controlled, oscillators, phase locked loops, frequency synthesizers, digital synthesis, power amplifiers etc.<br>Broadband systems: Overview of broadband and optical communication systems, Transceivers: Building blocks not covered in wireless systems such as broadband, amplifiers, transimpedance amplifiers, clock and data recovery circuits etc.<br>System level integration: Challenges in board level integration, Interconnects and transmission lines, Antennas | |
| 9. | **Reference(s):**<br>1. Thomas H. Lee, The Design of CMOS Radio-Frequency Integrated Circuits, 2nd edition, Cambridge University Press<br>2. Behzad Razavi, RF Microelectronics, 2nd Edition, Pearson Education India<br>3. Behzad Razavi, Design of Integrated Circuits for Optical Communications, 2nd edition, Wiley India<br>4. Selected IEEE journal publications | |