NUMERICAL LINEAR ALGEBRA

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INTENDED AUDIENCE : UG and PG students of technical institutions/ universities/colleges

COURSE OUTLINE :

This course is a basic course offered to UG/PG students of Engineering/Science background. It contains basics of matrix algebra, computer arithmetic, conditioning and condition number, stability of numerical algorithms, vector and matrix norms, convergent matrices, stability of non-linear systems, sensitivity analysis, singular value decomposition (SVD), algebraic and geometric properties of SVD, least square solutions, Householder matrices and applications, QR method, Power method and applications, Jacobi method for finding the eigenvalues of a given matrix. This course has tremendous applications in diverse fields of Engineering and Sciences such as control theory, image processing, numerical analysis and dynamical systems etc.

ABOUT INSTRUCTOR :

Prof. P. N. Agarwal is a Professor in the Department of Mathematics, IIT Roorkee. His area of research includes approximation Theory and Complex Analysis. He delivered 13 video lectures on Engineering Mathematics in NPTEL Phase I and recently completed Pedagogy project on Engineering Mathematics jointly with Dr. Uaday Singh in the same Department. Further he has completed online certification course “Mathematical methods and its applications” jointly with Dr. S.K. Gupta of the same department. He taught the course on “Integral equations and calculus of variations” several times to MSc (Industrial Mathematics and Informatics) students. He has supervised nine Ph.D. theses and has published more than 187 research papers in reputed international journals of the world. Currently, he is supervising eight research students.

Prof. D. N. Pandey is an Associate Professor in the Department of Mathematics, IIT Roorkee. Before joining IIT Roorkee, he worked as a faculty member in BITS-Pilani Goa campus and LNMIIT Jaipur. His area of expertise includes semigroup theory and functional differential equations of fractional and integral orders. He has already prepared e-notes for the course titled “Ordinary Differential Equations and Special Functions” under e-Pathshala funded by UGC. Also, he has published a book titled “Nonlocal Functional Evolution Equations: Integral and fractional orders, LAP LAMBERT Academic Publishing AG Germany”. He has delivered several invited talks at reputed institutions in India and abroad. He has guided three PhD theses and has published more than 60 papers in various international journals of repute. Currently, he is supervising five research students.

COURSE PLAN :

Week 1: Matrix operations and type of matrices, Determinant of a Matrix, Rank of a matrix, Vector Space-I, Vector Space-II
Week 2: Linear dependence and independence, Bases and Dimensions – I, Bases and Dimension - II, Linear Transformation - I, Linear Transformation - II
Week 3: Orthogonal subspaces, Row space, column space and null Space, Eigenvalues and Eigenvectors-I, Eigenvalues and Eigenvectors-II, Diagonalizable Matrices
Week 4: Orthogonal Sets, Gram Schmidt orthogonalization and orthonormal bases, Introduction to Matlab, Sign integer representation Computer representation of numbers
Week 5: Floating point representation, Round-off error, Error propagation in computer arithmetic, Addition and multiplication of floating point numbers, Conditioning and condition numbers-I
Week 6: Conditioning and condition numbers-II, Stability of numerical algorithms-I, Stability of numerical algorithms-II, Vector norms - I, Vector norms - II
Week 7: Matrix Norms - I, Matrix Norms-II, Convergent Matrices - I, Convergent Matrices - II, Stability of non-linear system
Week 8: Condition number of a matrix: Elementary properties, Sensitivity analysis-I, Sensitivity analysis-II, Residual theorem, Nearness to singularity
Week 9: Estimation of the condition number, Singular value decomposition of a matrix – I, Singular value decomposition of a matrix - II, Orthogonal Projections, Algebraic and geometric properties of matrices using SVD
Week 10: SVD and their applications, Perturbation theorem for singular values, Outer product expansion of a matrix, Least square solutions-I, Least square solutions-II
Week 11: Psudeo - inverse and least square solution, Householder matrices and their applications, Householder QR factorization –I, Householder QR factorization –II, Basic theorems on eigenvalues and QR method
Week 12: Power method, Rate of convergence of Power method, Applications of Power method with shift, Jacobi method-I, Jacobi method-II