

## DS 284: Numerical Linear Algebra (Murugesan Venkatapathi, #312 CDS)

Class Hours: Mon, Wed, Fri 11 AM -12 Noon

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Grading: X/100; Mid-term exam – 50; Final exam – 50.

### List of Topics:

*Introduction:* Matrix and vector norms, arithmetic and computational complexity, floating point arithmetic.

*Matrix factorization and direct methods for solving linear systems:* Gaussian elimination, LU factorization, Pivoting, Cholesky decomposition, QR factorization, Gram-Schmidt orthogonalization, Projections, Householder reflectors, Givens rotation, Singular Value Decomposition, Rank and matrix approximations, image compression using SVD, generalized Schur decomposition (QZ decomposition), Least squares and solution of linear systems and pseudoinverse, normal equations.

*Stability Analysis:* conditioning of a problem, forward and backward stability of algorithms, perturbation analysis.

*Eigenvalue problems:* Gershgorin theorem, Similarity transform, Eigenvalue & eigenvector computations, Power method, Schur decomposition, Jordan canonical form, QR iteration with & without shifts, Hessenberg transformation, Rayleigh quotient, Symmetric eigenvalue problem, Jacobi method, Divide and Conquer,

*Iterative methods:* Computing the Singular Value Decomposition, solving linear systems (Jacobi, Gauss-Seidel and SOR), convergence of iterative algorithms, Krylov subspace methods (Lanczos, Arnoldi, MINRES, GMRES, Conjugate Gradient and QMR), Pre-conditioners, Approximating eigenvalues and eigenvectors.

### Reference:

- *Numerical linear algebra* by Lloyd Nicholas Trefethen, David Bau
- *Matrix Analysis* by R. Bhatia, Springer, 1997.
- *Matrix Computations* by G. Golub and C. Van Loan, Johns Hopkins, third edition, 1996.
- *Matrix Analysis* by R.A. Horn and C.R. Johnson, Cambridge University Press, 1985.
- *Linear Algebra* by P. Lax, Wiley, 1997.
- *Iterative Methods for Sparse Linear Systems* by Y. Saad, PWS, 1997.
- *Applied Numerical Linear Algebra* by J. Demmel, published by SIAM, 1997
- *Matrix Analysis and Algorithms* by Andrew Stuart & Jochen Voss (2009)
- *Numerical Linear Algebra* by Grégoire Allaire, Sidi Mahmoud Kaber
- *Linear Algebra and Matrix Theory* by E.D. Nering, John Wiley, 1971.