

EAS 596 Topics List

Introduction to Numerical Mathematics for Data Scientists

Fall 2019

The following is the planned list and ordering of topics. This list is subject to change.

| Lecture | Topic | Trefethen | Strang | Fausett |
|---------|---|-----------|----------|---------|
| 1 | Introduction | | | |
| 1 | Introduction to Matlab | 9 | | 1.4 |
| 1 | Matlab – Functions and Scripts | | | 1.4 |
| 1 | Matlab – IDE | | | 1.4 |
| 1 | Matlab – Loops and logical statements | | | |
| 1 | Matlab – Example, Fibonacci sequence | | | |
| 2 | Approximation & Round-off Errors | Appendix | | 1.3 |
| 2 | Significant Figures | | | 1.2 |
| 2 | Numbering Systems | | | |
| 2 | Finite Precision Arithmetic | 13 | | |
| 2 | Floating Point Representations | 13 | | |
| 3 | Vectors – Introduction | 1 | 1.1 | |
| 3 | Vector Operations | 1 | 1.1 | |
| 3 | Dot Product | | 1.2 | |
| 3 | Schwartz Inequality | | 1.2 | |
| 4 | Triangle Inequality | | 1.2 | |
| 4 | Linear Combination of Vectors | | 1.1 | |
| 4 | Matrix – Introduction | 1 | 1.3 | |
| 4 | Matrix Operations | 1 | 2.4 | |
| 4 | Matrix – Vector | 1 | 1.3 | |
| 4 | Matrix Properties, Determinant, Trace | | 5.1 | |
| 4 | Matrix Inverses – Introduction | 1 | 2.5 | |
| 5 | Linear Systems of Equations – Introduction | | 2.1 | |
| 5 | Solution Existence and Uniqueness | | 2.2 | |
| 6 | Elimination & RREF | | 2.2 | |
| 6 | Use of Matrices: Graphs and Graph Theory | | 10.1 | |
| 6 | Use of Matrices: Markov Chains | | 10.3 | |
| 7 | Vector Spaces & Subspaces | | 3.1 | |
| 7 | Rules of a Vector Space | | 3.1 | |
| 7 | Span | | 3.1 | |
| 7 | Vector Independence | | 2.7 | |
| 7 | Linear Independence & Dependence | | 3.4 | |
| 7 | Basis | | 3.4 | |
| 7 | Vector Space Dimension | | 3.4 | |
| 8 | Functions | | | |
| 8 | Function Composition, Inverse | | | |
| 8 | Linear Transformations | | 8.1, 8.2 | |
| 8 | Sample Geometric Linear Operators in \mathbb{R}^3 | | | |

| Lecture | Topic | Trefethen | Strang | Fausett |
|----------------|--|------------------|---------------|----------------|
| 9 | Column Space | 1 | 3.1, 3.5 | |
| 9 | Nullspace | 1 | 3.2, 3.5 | |
| 9 | Row Space | 1 | 3.4, 3.5 | |
| 9 | Left Nullspace | | 3.5 | |
| 9 | Rank-Nullity (Dimension) Theorem | | 3.5 | |
| 9 | Orthogonality | | 4.1 | |
| 9 | Orthogonality of the Four Matrix Subspaces | | 4.1 | |
| 10 | Numerical Solutions – Introduction | | 11.1 | |
| 10 | Matrix & Vector Norms | 3 | 11.2 | |
| 10 | Condition Number | 12 | 11.2 | |
| 10 | LU Decomposition & Gaussian Elimination | 20, 21 | 2.6 | 4.1 |
| 10 | Operation Count of LU | 20 | 11.1 | |
| 10 | Failure of LU due to Finite Precision | 20 | 11.1 | |
| 11 | Projections on Subspaces | 6 | 4.2 | |
| 11 | Least Squares Approximation | 11 | 4.3 | |
| 12 | Normal Equations | | 4.2 | |
| 12 | Orthogonal & Orthonormal Basis | | 4.4 | |
| 12 | QR | 7 | 4.4 | |
| 12 | Classical Gram-Schmidt | 8 | 4.4 | |
| 13 | Modified Gram-Schmidt | 8 | 4.4 | |
| 13 | Householder Triangularization | 10 | 11.1 | 4.2 |
| 13-14 | Eigensystems | 24 | 6.1 | 5 |
| 14 | Normal Matrix | | | |
| 14 | Matrix Diagonalization | | 6.2 | |
| 14-15 | Iterative Eigensolvers | 25-30 | | 5.1-5.3 |
| 15 | SVD | 4, 5, 31 | 7.1, 7.2, 7.4 | 5.4 |
| 16 | Scalar Differential Equations | | | |
| 16-17 | Solution of Linear ODEs | | | |
| 17-18 | PDEs | | | |
| 18-19 | Systems of ODEs | | 6.3 | |
| 19 | Finite Difference | | | 14.2 |
| 19 | IVPs | | | 12 |
| 20 | Multistage Methods | | | 12.2 |
| 20-21 | Runge-Kutta Schemes | | | 12.2 |
| 21 | Multi-Step Methods | | | 13.3 |
| 21 | BVPs | | | 15.3 |
| 22 | IVP + BVP | | | 15 |
| 22 | Root Finding | | | 2 |
| 23 | Systems of Nonlinear Equations | | | 7 |
| 23 | Minimization | | | 2.5 |
| 24 | Multidimensional Minimization | | | 7.2 |
| 25 | Nonlinear Regression | | | |
| 25 | Interpolation | | | 8 |
| 26 | Integration | | | 11.2 |