# 18.330: Introduction to Numerical Analysis

Project Proposal & Final Project

due November $30^{th}$ & December $11^{th}$ @ 11:59 pm

The final project is a great opportunity for you to learn about some area of numerical analysis that was not covered in-depth during the course. Try to aim for a topic that you think you could give a 75 minute lecture on (e.g., not too narrow, but also not requiring multiple lectures to understand the big ideas). The project consists of two parts:

**Project Proposal:** First, by November $30^{th}$, please upload a one page project proposal detailing the subject matter you would like to cover in your final project. A number of sample topics are listed on the following page, but feel free to suggest something not on this list. More than one student may choose a certain topic – however, if a large number of people choose the same topic, they may be asked to suggest a different subject. In addition to detailing the topic you would like to write about, feel free to also give a brief sketch/small amount of details on the different aspects of the topic you would like to cover as well as the references you intend to use. The project proposal is due **November $30^{th}$ @ 11:59 pm**. The project proposal is worth **5 points**. Submitting a well-thought out proposal on-time will result in an automatic grade of 5 out of 5. **Late submissions will receive no credit**.

**Final Project:** Once your project proposal has been approved, you are ready to start writing your final project. There is no formal requirement on page length/word count for the project – the only requirement is that the amount of content is roughly equivalent to the material needed for one 75 minute lecture. This should usually require $5 - 10$ typed pages of material, but may vary by topic (and formatting). The report should serve as a thorough yet accessible introduction to a topic not extensively covered in class, that your classmates should be able to read and understand without additional references. LaTeX is recommended for formatting, but feel free to use whatever text editor you are most comfortable with. The final project is due **December $11^{th}$ @ 11:59 pm** and is worth **25 points**. The report will be judged based on five categories:

- overall structure (**5 pts**): Is the flow of the presentation well thought-out? Does the order and connections between ideas throughout make sense?
- mathematical clarity (**5 pts**): Is everything well-defined? Are arguments and discussions mathematically precise? If a concept is intentionally presented informally, is the informal nature explicitly noted?
- mathematical correctness (**8 pts**): Is the report mathematically correct? Are there any mathematical errors?
- technical writing (**5 pts**): Is the report well-written? Do the sentences clearly convey the information? Is the document free of grammatical errors and typos?
- citing sources (**2 pts**): Are all the sources used in the project properly cited?

All sources used for your report must be formally cited, and collaboration between students is not allowed for this project. **Late submissions will receive no credit**.

## Sample Project Ideas:

- bounds for eigenvalues and eigenvectors of perturbed matrices
- Brownian motion and stochastic differential equations
- the inverse power method & Rayleigh quotient iteration
- the QR algorithm (with shifts) for arbitrary unsymmetric matrices
- the bisection method for diagonalizing a matrix
- modern algorithms for computing $\sqrt{x}$
- computing matrix $\|\cdot\|_p$ norms, $p \in [1, \infty)$
- the growth factor in Gaussian elimination
- conjugate gradient method
- GMRES algorithm
- Lanczos method and Arnoldi iteration
- summation algorithms in floating point
- multigrid methods
- successive over-relaxation
- Jacobi's eigenvalue algorithm
- estimating the determinant of a matrix
- hyperbolic partial differential equations
- quadrature for singular integrals
- numerical solutions to Navier Stokes
- fast matrix multiplication
- Hermite interpolation
- rational interpolation
- singular value decomposition
- Tikhonov regularization
- trigonometric interpolation
- Bezier curves
- romberg integration
- Runge-Kutta methods
- shooting methods
- finite element method
- Nystrom's method
- collocation method
- interval arithmetic
- fast fourier transform
- the simplex method
- sturm sequences
- gradient descent
- Bairstow's method
- random number generation
- Monte carlo methods
- statistical roundoff
- fast multipole method
- vector quantization
- Muller's method
- stiff differential equations
- homotopy methods

**NOTE**: Feel free to suggest something not on this list!