# Math 446, Spring 2022 - Course content

Suddhasattwa Das*

February 2, 2022

**Instructor.** Suddhasattwa Das (Shuddho).

**Class location.** The entire course will be taught asynchronously.

**Office hours.** Wednesday, Thursday, 5:30–6:30 pm, online on the Zoom meeting room sent via email.

**Software requirements.** This course is meant for you to acquire advanced computation skills. Computation and programming is an integral part of this course. The demonstrations in the class will only be in **Julia**. However, students are allowed to submit their computation based assignments in **any** of the following languages

(i) Julia : open-source, high precision, high-speed, most-modern software.
Read more here : https://julialang.org/
Installation links : https://julialang.org/downloads/

(ii) Matlab : a commerical computation software, available on campus in the computer labs (if you are on campus). Students can also purchase the software for their personal computers. There is also a **free student version** which GMU students can access by logging in using their GMU email and password. There are plenty of Matlab tutorials on the internet. There is a comprehensive tutorial at Mathworks, and another one in the textbook's appendix.

(iii) Python : open-source software, used in majority of industrial applications : https://www.python.org/downloads/
All the above languages are powerful computation softwares with good libraries and graphing capability.

(iv) C, C++ : users of these languages need to find the suitable linear algebra packages, and graphing / plotting.

Some of you may have had programming experience before in one or more of the above languages. You are welcome to choose a language of your liking. If you have had no prior experience with programming before, I would recommend Julia. It is syntactically simple and high level like Python or Matlab. However, it is the fastest of all of the above languages. It is also both compiled and interpreted.

**Grade distribution.** You will be evaluated based on your performance on 5 homework projects, 1 midterm and 1 final exam, and mini-quizzes pertaining to each lesson. Homework will be given regularly, **but not graded**.

*Department of Mathematical Sciences, George Mason University, Virginia, USA

| Category | % of total score |
|---|---:|
| Mini-quizzes | 10 |
| Projects(5) | 60 |
| Midterm | 10 |
| Final Exam | 20 |
| Total | 100 |

**Course content.** The course will cover portions of Chapters 1-5 of the book mentioned above. Here is the breakdown :

1. Floating point arithmetic :
   1.1 Binary and decimal representations, conversion from one to another.
   1.2 Representation of real numbers
   1.3 Floating point arithmetic.
   1.4 Loss of significance during arithmetic operations.
2. The solution of nonlinear equations in one variable
   2.1 Bisection method :
   2.2 Fixed point iteration :
   2.3 Newton's method :
   2.4 Secant method :
   2.5 Method of false position
3. Error analysis
   3.1 Forward and backward error
   3.2 Cause for large and small backward and forward errors.
4. The solution of systems of linear equations
   4.1 Gaussian elimination : technique, complexity.
   4.2 LU factorization : connection with Gaussian elimination; back-substitution; complexity.
   4.3 Condition number : sources of error; swamping.
   4.4 LUP factoriations : permutation matrix, partial pivoting.
   4.5 Iterative Methods
   4.6 Cholesky factorization for symmetric, positive definite matrices.
5. Least squares problems
   5.1 Inconsistent systems of equations
   5.2 Least Squares and the Normal Equations
   5.3 Gram–Schmidt orthogonalization and least squares
   5.4 QR Factorization
   5.5 Generalized Minimum Residual (GMRES) Method

6. Nonlinear least squares problems
   6.1 Gauss–Newton Method
   6.2 Models with nonlinear parameters
   6.3 Levenberg–Marquardt Method
7. The solution of nonlinear systems
   7.1 Multivariate Newton's Method
   7.2 Broyden's method (time permitting)
8. Interpolation and polynomial approximation
   8.1 Data and Interpolating Functions
   8.2 Lagrange interpolation
   8.3 Application of Linear least squares to interpolation
   8.4 Interpolation Error - various formulas
   8.5 Splines - cubic splines, properties, endpoint criterion
   8.6 Bézier Curves (time permitting)
9. Numerical integration and differentiation
   9.1 Finite difference formulas
   9.2 Quadrature formulas
   9.3 Adaptive quadratures