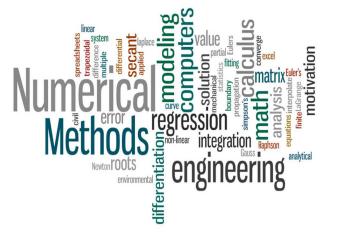# CE 5310: Numerical Methods in Engineering

NUMERICAL ANALYSIS
SECOND EDITION

TIMOTHY SAUER

Textbook is useful as a reference and advanced study. I will not be following the textbook closely but could assign readings & homeworks.
So having access to the book is essential

Instructor: Venki Uddameri, Ph.D. P.E.; Professor CECE

Contact Info: Ph: 806-834-8340; email: venki.uddameri@ttu.edu

Class Timing: 6:30 pm - 7:50 pm, TR

Class Location: Online (Link will be provided)

Office Hours: Email for an appointment

Required Pre-requisites:
Calculus through differential equations. Some familarity with partial differential equations is desirable but not necessary. Working knowledge of computer programming is a must.

I will be using Python programming environments in my illustrative examples. In addition to being free, It is also the state-of-the art, industry standard software for numerical analysis.

Numerical Methods engineering modeling computers regression integration differentiation roots math calculus matrix analysis motivation error solution value

Why Numerical Methods?

- Solve equations where exact methods do not work

- Reduce complexity of calculations
  - Convoluted convolutions

- Model engineering systems more realistically
  - Capture nonlinearity and heterogeneity

- Automate complex calculations
  - 1000 equations with 1000 unknowns

$$\frac{1}{\sqrt{2\pi}} \int_{-\infty}^{x} \exp\left(-\frac{u^2}{2}\right) du,$$

Why take this Course?

Are you interested in learning about what drives advanced modeling software and tools such as those based on finite elements?

Do you like to understand how engineers use computers to understand the behavior of complex engineering systems?

Do you like to extend the techniques that you learned in your linear algebra and calculus classes?

Do you want to sound cool in engineering cocktail parties and impress your friends?

⚠️ This course assumes you have working knowledge of a programming language or a mathematical environment (Preferably Python and/or R). The transition to these languages is easier if you have programmed in another language (e.g., C, C++ or MATLAB) before. If you are not comfortable with programming, I recommend you taking CE 5331: Computational Skills for Engineers (aka Python Bootcamp) before taking this class or use other means to get comfortable with programming.

Tentative Syllabus

Week 1	Introduction to the class; Short Introduction to Python; Numerical errors and approximations	Module 0
Week 2	Roots of Equation	Module1 - Root Finding
Week 3 through Week 5	Gaussian and LU factorization; Jacobi and Gauss Siedel Positive Definite Matrix, Choleskey decomposition; Banded Matrices; Eigen values, power and inverse power methods QR method and its variantsQR method and its variants, SVD	Module 2 - Matrix Methods
Week 6 - Week 7	Interpolation in single and multiple dimensions; Linear and Nonlinear optimization; Regression	Module 3: Interpolation and Optimization
Week 8	Numerical Integration – Newton Cotes Numerical Integration – Romberg and Quadrature methods	Module 4: Integral Calculus
Week 9 - Week 11	Numerical Differentiation of ODEs; Predictor-Corrector; Runge-Kutta and Adaptive Methods for solving IVP and BVP problems	Module 5: ODEs
Week 12 - Week 14	Finite Difference Equations for Solving PDEs; Forward and Centered Differences; Solution of Elliptic, Hyperbolic and Parabolic Partial Differential Equations using iterative, explicit and implicit methods	Module 6: PDEs
Week 15	Review and Wrap Up	

The Instructor reserves the right to change the tentative outline presented above baed on an assessment of the class progress and other extenuating factors outside the control of the instructor. These changes, if any, will be applied uniformly to all students.

Grading		
Assignments	60%	Roughly 1 Assignment per week
Quizzes	20%	Quizzes will be on the Blackboard or on zoom (inclass)
Final Project	15%	Will include a research/practical application of methods learned in the class
Class Participation	5%	Attendance alone is insufficient. Please speakup and ask and answer questions to get full credit

The instructor reserves the right to change the weights and testing elements to be used. These changes if any will be applied uniformly to all students.

The overall letter grades for the class will be assigned as follows: A ≥ 90%, ≥ 80 & < 90% B, ≥ 70 & < 80% C, ≥60 & < 70% D and < 60% F. I may assign + and – grades to qualitatively indicate student's performance in the class. According to current TTU policies, + and – grades do not change the overall GPA of the student which is based on the letter grade alone.

Electronic Resources:
Classes will be held online in synchronous mode. Zoom link will be sent to the class using Outlook Calendar.

Blackboard will be used to communicate with students asychnronously. Assignments will be posted on the blackboard. The grade center of the blackboard will also be made use of.

Please make sure you are checking the email linked to the blackboard so you are receiving notifications sent via blackboard.

Code snippets and scripts will be provided via github with links provided on https://uddameri.com/python-notebooks/

You are required to have a Personal Computer or a laptop with at least 16 GB RAM and sufficient hard-disk space. We will be using Python (www.python.org) through Anaconda Environment (www.anaconda.com). I will use Linux (Debian/Ubuntu) but you are feee to use any operating system of your choice.

The instructor reserves the right to share the zoom recordings of the lectures as he deems fit. If these lectures are shared, they will be posted on TTU One-drive. Please note that as a synchronous class, the instruction is under no obligation to post these lecture notes. In addition, the timing of when these notes will be posted, if any, will be up to the discretion of the instructor. In other words, do not rely on lectures being posted to keep up with the class.

You are explicitly prohibited from recording lectures using any means due to FERPA regulations and other applicable policies of the University.

ADA STATEMENT:

Any student who, because of a disability, may require special arrangements in order to meet the course requirements should contact the instructor as soon as possible to make any necessary arrangements. Students should present appropriate verification from Student Disability Services during the instructor's office hours. Please note: instructors are not allowed to provide classroom accommodations to a student until appropriate verification from Student Disability Services has been provided. For additional information, please contact Student Disability Services in West Hall or call 806-742-2405.

ACADEMIC INTEGRITY STATEMENT:

Academic integrity is taking responsibility for one's own class and/or course work, being individually accountable, and demonstrating intellectual honesty and ethical behavior. Academic integrity is a personal choice to abide by the standards of intellectual honesty and responsibility. Because education is a shared effort to achieve learning through the exchange of ideas, students, faculty, and staff have the collective responsibility to build mutual trust and respect. Ethical behavior and independent thought are essential for the highest level of academic achievement, which then must be measured. Academic achievement includes scholarship, teaching, and learning, all of which are shared endeavors. Grades are a device used to quantify the successful accumulation of knowledge through learning. Adhering to the standards of academic integrity ensures grades are earned honestly. Academic integrity is the foundation upon which students, faculty, and staff build their educational and professional careers. [Texas Tech University ("University") Quality Enhancement Plan, Academic Integrity Task Force, 2010]

RELIGIOUS HOLIDAY STATEMENT:

"Religious holy day" means a holy day observed by a religion whose places of worship are exempt from property taxation under Texas Tax Code §11.20. A student who intends to observe a religious holy day should make that intention known in writing to the instructor prior to the absence. A student who is absent from classes for the observance of a religious holy day shall be allowed to take an examination or complete an assignment scheduled for that day within a reasonable time after the absence. A student who is excused under section 2 may not be penalized for the absence; however, the instructor may respond appropriately if the student fails to complete the assignment satisfactorily.

DISCRIMINATION, HARASSMENT, AND SEXUAL VIOLENCE STATEMENT:

Texas Tech University is committed to providing and strengthening an educational, working, and living environment where students, faculty, staff, and visitors are free from gender and/or sex discrimination of any kind. Sexual assault, discrimination, harassment, and other Title IX violations are not tolerated by the University. Report any incidents to the Office for Student Rights & Resolution, (806)-742-SAFE (7233) or file a report online at titleix.ttu.edu/students. Faculty and staff members at TTU are committed to connecting you to resources on campus. Some of these available resources are: TTU Student Counseling Center, 806- 742-3674, https://www.depts.ttu.edu/scc/(Provides confidential support on campus.) TTU 24-hour Crisis Helpline, 806-742-5555, (Assists students who are experiencing a mental health or interpersonal violence crisis. If you call the helpline, you will speak with a mental health counselor.)

CIVILITY IN THE CLASSROOM STATEMENT:

Texas Tech University is a community of faculty, students, and staff that enjoys an expectation of cooperation, professionalism, and civility during the conduct of all forms of university business, including the conduct of student–student and student–faculty interactions in and out of the classroom. Further, the classroom is a setting in which an exchange of ideas and creative thinking should be encouraged and where intellectual growth and development are fostered. Students who disrupt this classroom mission by rude, sarcastic, threatening, abusive or obscene language and/or behavior will be subject to appropriate sanctions according to university policy. Likewise, faculty members are expected to maintain the highest standards of professionalism in all interactions with all constituents of the university (www.depts.ttu.edu/ethics/matadorchallenge/ethicalprinciples.php).

LGBTQIA SUPPORT STATEMENT:

I identify as an ally to the lesbian, gay, bisexual, transgender, queer, intersex, and asexual (LGBTQIA) community, and I am available to listen and support you in an affirming manner. I can assist in connecting you with resources on campus to address problems you may face pertaining to sexual orientation and/or gender identity that could interfere with your success at Texas Tech. Please note that additional resources are available through the Office of LGBTQIA within the Center for Campus Life, Student Union Building Room 201, www.lgbtqia.ttu.edu, 806.742.5433."