THE UNIVERSITY OF TEXAS AT AUSTIN
Department of Biomedical Engineering

BME 313L INTRODUCTION TO NUMERICAL METHODS IN BIOMEDICAL ENGINEERING
Fall 2021

SYLLABUS

Unique Number: 15040

Instructor:
Prashant K. Jha
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Office hours: **Wednesday 6 – 7.30 pm** (online)
Thursday 6 – 7.30 pm (online)

Time: **MWF 11 am – 12 pm**

Location: **BUR 216**

Teaching Assistant: Chungmin Han (Email: cmhan616@utexas.edu)
Office hours: **Thursday, 6 – 8 pm** (online)

Learning Assistants: Maria Amador (Email: m.amador@utexas.edu)
Office hours: **Monday, 2 – 3.30 pm** (online)

Parth Malaviya (Email: parthmalaviya@utexas.edu)
Office hours: **Thursday, 8 – 9.30 am** (online)

Sung Jung (Email: sunghjung3@utexas.edu)
Office hours: **Thursday, 9.30 – 11 am** (online)

Lab Hours:

1. **Tuesday 9:30 am – 12:30 pm**
   Unique number: 15040
   Location: **BME 3.312**
   Chungmin, Maria (9.30 am – 11 am)

2. **Tuesday 3:30 pm – 6:30 pm**
   Unique number: 15050
   Location: **ETC 2.132**
   Chungmin, Sung (3.30 pm – 5 pm)

3. **Thursday 12:30 pm – 3:30 pm**
   Unique number: 15045
   Location: **BME 3.312**
   Chungmin, Parth (12.30 pm – 2 pm)

Web Page: Canvas: https://utexas.instructure.com/courses/1320074, Another website**:** https://prashjha.github.io/BME-313L-website/

Catalog Description:

Introduces principles and techniques of numerical analysis of biomedical engineering problems. Examines numerical methods of integration, differentiation, interpolation, curve fitting, data analysis, sampling and estimation, error analysis, analysis of ordinary differential equations, numerical modeling of biomedical engineering systems, symbolic computation, and scientific visualization.

Course Objectives:
To develop the student's understanding of and ability to use computers and numerical algorithms to solve engineering problems.

Prerequisite(s) or Co-requisites(s):
The following coursework with a grade of at least C-: Biomedical Engineering 303 or Computational Engineering 301, Biomedical Engineering 303L, and Mathematics 427J.

Knowledge, Skills, and Abilities Students Should Have Before Entering This Course:
A first course in MATLAB programming, Calculus, Differential Equations (co-requisite).

Knowledge, Skills, and Abilities Students Gain from this Course (Learning Outcomes):
Understanding how computers can be used to simulate engineering systems, introductory linear algebra, knowledge of standard numerical methods and how they are implemented for linear systems, basic nonlinear systems, and elementary differential equations, all using MATLAB.

Textbook(s):
Steven C. Chapra, Applied Numerical Methods with Matlab for Engineers & Scientists, 3rd Ed., McGraw-Hill, 2012.
*4th Edition of above book could also be used. However, the instructor/TA will use 3rd Edition as main reference.

Other Required Materials:
For hands-on programming lectures, students are advised to bring a laptop. Students will be informed whenever possible of such lectures.

Topics:
Students will write programs implementing different methods and compare them for engineering applications for various topics mentioned below. The list of topics covered is as follows:

1. Introduction to MATLAB (4 lectures) (Ch. 2,3)
2. Sources of Error in Computer Arithmetic and Algorithms (1 lecture) (Ch. 4)
3. Roots and optimization (4.5 lectures) (Ch. 5 – 7)
4. Linear Systems of Equations (7.5 lectures) (Ch. 8, 9, 12)
5. Eigenvalues and Eigenvectors (2.5 lectures) (Ch. 13)
6. Regression, curve fitting, least squares (4 lectures) (Ch. 14 – 15)
7. Polynomial Interpolation (3 lectures) (Ch. 17)
8. Numerical Integration (2.5 lectures) (Ch. 19, 20)
9. Numerical Differentiation (2.5 lectures) (Ch. 21)
10. Solving Differential Equations, ODE (IVP), ODE (BVP) (4 lectures) (Ch. 22, 24)
11. Brief introduction to Artificial Neural Networks and their applications (3 – 4 lectures)

Lecture Number	Lecture Date	Topics covered	Reading Assignment	Assignment/Project
1	Wed 8/25	Syllabus and Introductions	NA	
2	Fri 8/27	Topic 1	Ch. 2	
3	Mon 8/30	Topic 1	Ch. 2	
4	Wed 9/1	Topic 1	Ch. 3	
5	Fri 9/3	Topic 1	Ch. 3	
6	Wed 9/8	Topic 2	Ch. 4	A1

7	Fri 9/10	Topic 3	Ch. 5	
8	Mon 9/13	Topic 3	Ch. 5, 6	
9	Wed 9/15	Topic 3	Ch. 6	A1 Due
10	Fri 9/17	Topic 3	Ch. 7	
11	Mon 9/20	Topic 4	Ch. 8	A2
12	Wed 9/22	Topic 4	Ch. 8,9	
13	Fri 9/24	Topic 3, 4	Ch. 6, 11	
14	Mon 9/27	Topic 4	Ch. 8	
15	Wed 9/29	Topic 4	Ch. 9	A2 Due
16	Fri 10/1	Topic 4	Ch. 9	
17	Mon 10/4	Topic 4	Ch. 10	
18	Wed 10/6	Topic 4	Ch. 12	
19	Fri 10/8	Topic 4, 5	Ch. 12, 13	P1
20	Mon 10/11	Topic 5	Ch. 13	
21	Wed 10/13	Topic 5	Ch. 13	
22	Fri 10/15	Topic 6	Ch. 14	
23	Mon 10/18	Topic 6	Ch. 14, 15	
24	Wed 10/20	Topic 6	Ch. 15	A3
25	Fri 10/22	Topic 6	Ch. 15	P1 Due
26	Mon 10/25	Review (Topic 4 – 6)	Ch. 15	
27	Wed 10/27	Review (Topic 4 – 6)	Ch. 17	
28	Fri 10/29	Review (Topic 4 – 6)	Ch. 17	
29	Mon 11/1	Topic 7	Ch. 17, 19	P2, A3 Due
30	Wed 11/3	Topic 7	Ch. 19	
31	Fri 11/5	Topic 7	Ch. 19, 20	
32	Mon 11/8	Topic 8	Ch. 20, 21	
33	Wed 11/10	Topic 8	Ch. 21	
34	Fri 11/12	Topic 8	Ch. 21	A4
35	Mon 11/15	Topic 9	Ch. 22	P2 Due
36	Wed 11/17	Topic 9	Ch. 22	
37	Fri 11/19	Topic 9	Ch. 24	A4 Due, A5
38	Mon 11/22	Topic 10	Ch. 24	
39	Mon 11/29	Topic 11		A5 Due, A6
40	Wed 12/1	Topic 11		
41	Fri 12/3	Topic 11		
42	Mon 12/6	Topic 11, Review		A6 Due
Final Exam				
	Final project	Topics 1 – 11		

*A1 – Assignment 1, A2 – Assignment 2, so on. P1 – Project 1, P2 – Project 2

Lab Sessions:
Tentative lab sessions and the topics covered in the sessions are listed below:

Lab Number	Week Number	Dates	Topic	Comments
1	2	8/30 – 9/3	1	MATLAB basics
2	4	9/13 – 9/17	1,2	MATLAB advance, Computing errors
3	5	9/20 – 9/24	3	Roots
4	6	9/27 – 10/1	4	Linear algebra and Gauss elimination
5	7	10/4 – 10/8	1 – 4	Review
6	8	10/11 – 10/15	4	Iterative methods
7	9	10/18 – 10/22	5	Eigenvalues

8	10	10/25 – 10/29	6	Regression and curve fitting
9	11	11/1 – 11/5	5 – 6	Review
10	12	11/8 – 11/12	7	Polynomial interpolation
11	13	11/15 – 11/19	8	Numerical integration
12	15	11/29 – 12/3	9	Numerical differentiation

Grading:
Attendance, active participation, pop-quizzes, lab reports: 10%
Homework: 30% (6 assignments, we will count best 4 out of 6)
Projects: 35% (2 projects, 20% - project 1, 15% - project 2)
Final Project: 25%

Grading slabs

A	A-	B+	B	B-	C+	C	C-	D+	D	D-	F
> 90 ≤ 100	> 87 ≤ 90	> 84 ≤ 87	> 80 ≤ 84	> 77 ≤ 80	> 74 ≤ 77	> 70 ≤ 74	> 67 ≤ 70	> 64 ≤ 67	> 60 ≤ 64	> 55 ≤ 60	≤ 55

Note: We will follow university guidelines in enforcing regular attendance. Whether it is an online or in-person class, active participation from students is expected. The penalty could be higher for those students who show significantly less interest in the class activity. In addition, students disrupting the class or learning process of other students will be fined (in terms of total grade) heavily.

Laboratory Assignments:
You would need to submit the lab reports towards the end of lab session. The report will be used to determine whether the student was paying attention during the session and whether the practice problems are completed. The penalty, in case the report is not submitted or partial report is submitted, will be applied. The total (over whole semester) penalty in these cases is maximum up to 10%. (See *Grading* section).

Class Format:
We will have three one-hour lectures per week. As of now, we will have **In-Person Class (Face-to-face)**.

Homework Policy:
1. There will be a total of 6 assignments; however, in the end, we will only consider the best 4 out of 6.
2. Assignment will be due in a week from the day it is assigned.
3. Up to 4 days of delay is allowed. However, each passing day you will lose 20% of the marks.
4. It is possible to allow late submission. You need to explain the reason for the late submission, and only if the instructor has confirmed you can submit the assignment late. The instructor retains the right to decide on this matter.
5. In case you are going through an emergency, do not worry about the late submission. You can submit the assignment once you are out of the crisis. Of course, late submission, in this case, will only be accepted if the reasons you have provided are valid. The instructor retains the right to decide on this matter.
6. Assignments must be completed without any collaboration or help. There will be a penalty if we find signs of plagiarism.
7. Codes developed to complete the assignments should also be independent, and graders will check if plagiarism or code is copied from online sources.

Examinations:
To encourage collaboration and exchange of knowledge, we will assign two projects. Some key points:
1. Projects will be more challenging compared to the assignments.
2. We will form a group of 5 students (group will be formed randomly), and each group will complete the project.
3. The final report that you will submit has to be prepared individually (i.e., you will collaborate with your group members but will prepare reports separately).
4. Unlike assignments, you will be given 2 weeks to complete each project.

Note: We will follow the rules described in the *Homework Policy* section above regarding the late submissions.

Attendance:
Regular attendance is expected. Students are responsible for the information covered in class.

Office Hours:
Office hours will be listed after considering the best time for students. Additionally, appointments can be made with the instructor via e-mail. We may also have online office hours. The details will be available after the first class.

Important Dates:
Aug 25: First class
Sep 10: Last day to add/drop a course with refund
Dec 6: Last class day
More details can be found here: https://registrar.utexas.edu/calendars/21-22

Project and Exam Dates
Oct 8: Project 1 assigned
Oct 22: Project 1 due
Oct 30: Project 2 assigned
Nov 16: Project 2 due
Nov 22 - 25: Final project assigned
Dec 10 - 13: Final project due

No-class Dates
Sep 6, Nov 24, Nov 26

No-lab Weeks
Week 1 (8/23 – 8/27), Week 3 (9/6 – 9/10), Week 14 (11/22 – 11/26)

Professionalism Topics:
Assignments will include effective written and graphical communication. All work must be the student's original work. Collaboration with other students is allowed and encouraged, but copying of solutions is strictly forbidden.

Design Assignments:
None.

Computer:
All assignments will have a computational component. MATLAB will be used throughout the course. GNU Octave (http://www.gnu.org/software/octave/) can be used instead.

Impact on Subsequent Courses in Curriculum:
The course increases students' familiarity with computers and computer programming and how these are used with computational methods to study engineering problems.

Relationship of Course to Program Outcomes:
This course contributes to the ABET Criterion 3 student outcomes listed below. For more information, see *Criteria for Accrediting Engineering Programs, 2021-2022* at https://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2021-2022/.

STUDENT OUTCOME	
1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	√

2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	
3. an ability to communicate effectively with a range of audiences	
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies	√

PROGRAM CRITERIA	
A. Applying principles of engineering, biology, human physiology, chemistry, calculus-based physics, mathematics (through differential equations) and statistics	√
B. Solving bio/biomedical engineering problems, including those associated with the interaction between living and non-living systems	√
C. Analyzing, modeling, designing, and realizing bio/biomedical engineering devices, systems, components, or processes	√
D. Making measurements on and interpreting data from living systems	√

Special Notes:
The University of Texas at Austin provides upon request appropriate academic adjustments for qualified students with disabilities. For more information, contact the Office of the Dean of Students at 471-6259, 471-4641 TDD or the Cockrell School of Engineering Director of Students with Disabilities at 471-4321.

Evaluation:
Note that the Measurement and Evaluation Center forms for the Cockrell School of Engineering will be used during the last week of class to evaluate the course and the instructor. They will be conducted in an electronic format for Spring 2021. You may also want to note any other methods of evaluation you plan to employ.

COVID-19 Updates: Fall 2021 Semester

Classroom Safety and COVID-19
To help preserve our in person learning environment, the university recommends the following.

- **Adhere to university mask guidance** (https://tinyurl.com/UTMaskGuidance)**.** Masks are strongly recommended indoors regardless of vaccination status.
- **Vaccinations are widely available**, free and not billed to health insurance. The vaccine will help protect against the transmission of the virus to others and reduce serious symptoms in those who are vaccinated. Visit https://uthealthaustin.org/patient-resources/covid-19-updates/covid-19-vaccination for more information.
- **Proactive Community Testing** remains an important part of the university's efforts to protect our community. Tests are fast and free. Visit https://healthyhorns.utexas.edu/coronavirus_proactive_testing.html for more information.
- Visit **protect.utexas.edu** for updated information and announcements from the university.

Reduced Classroom Density and Social Distancing
None as of now.

Seating Charts for Contact Tracing
None as of now.

Sharing of Course Materials is Prohibited
No materials used in this class, including, but not limited to, lecture hand-outs, videos, assessments (quizzes, exams, papers, projects, homework assignments), in-class materials, review sheets, and additional problem sets, may be shared online or with anyone outside of the class unless you have my explicit, written permission. Unauthorized sharing of materials promotes cheating. It is a violation of the University's Student Honor Code and an act of academic dishonesty. I am well aware of the websites used for sharing materials, and any materials found online that are associated with you, or any suspected unauthorized sharing of materials, will be reported to Student Conduct and Academic Integrity in the Office of the Dean of Students. These reports can result in sanctions, including failure in the course.

Class Recordings
If we decide to record the lectures, following disclaimer applies

Class recordings are reserved only for students in this class for educational purposes and are protected under FERPA. The recordings should not be shared outside the class in any form. Violation of this restriction by a student could lead to Student Misconduct proceedings. Guidance on public access to class recordings can be found here.

Prepared by: Prashant K. Jha Date: 08/22/2021 (updated on 10/31/2021)