King Fahd University of Petroleum and Minerals

Department of Mathematics & Statistics

Math 472 Syllabus, Term 191

Coordinator: Dr. Kareem Elgindy

Office: 5-415 -- Email: kareem.elgindy@kfupm.edu.sa

The Course Code and Name: Math 472, Numerical Analysis II.

The Course Credit Hours: 3-0-3 (Two lecture sessions per week.)

Lectures: Monday & Wednesday, 03:30-04:45 pm, 4-106.

Office Hours: Monday & Wednesday, 09:15-11:15 am, 5-415 (or by appointment.)

The Course Objective: This is the second part of the undergraduate Numerical Analysis course that aims to cover more advanced numerical methods to solve problems that arise in the applied sciences and engineering. We will cover many practical applications of numerical analysis such as interpolation, polynomial approximation, adaptive approximation, numerical differentiation and integration, IVPs and BVPs of ODEs, IVPs of stiff ODEs, and data fitting. The course also aims to reinforce the understanding of the sources, significance, calculation, and interpretation of numerical errors associated with numerical computations. In order to make the presentation concrete and appealing we adopt the programming environment MATLAB as a faithful companion to analyze and solve a range of problems numerically.

The Course Content: Approximation of functions: Polynomial interpolation, spline interpolation, least squares approximation, and adaptive approximation. Numerical differentiation. Numerical integration: Basic and composite rules, Gaussian quadrature, and Romberg integration. Solution of ODEs: Euler, Taylor series, and Runge-Kutta methods for IVPs, multistep methods for IVPs, systems of first-order IVPs, higher-order IVPs. Shooting and finite difference methods for BVPs. Stiff differential equations.

The Course Prerequisite: MATH 371 or CISE 301.

Textbook: R.L. Burden, J.D. Faires, and A.M. Burden. Numerical Analysis. Cengage Learning, 10th edition, 2015.

Optional MATLAB Textbooks and References:

- Desmond J. Higham and Nicholas J. Higham. MATLAB Guide, volume 150. Siam, 3rd edition, 2016.
- Brian R. Hunt, Ronald L. Lipsman, and Jonathan M. Rosenberg. A Guide to MATLAB: For Beginners and Experienced Users. Cambridge University Press, 3rd edition, 2014.

Online MATLAB Tutorials:

- MATLAB® Primer.
- "Introduction to MATLAB," MITOpenCourseWare.
- Christos Xenophontos. A Beginner's Guide to MATLAB. Department of Mathematical Sciences, Loyola College, 2002.

Online MATLAB Video Tutorials:

- MATLAB Training.

MATLAB Codes:

- The Textbook Algorithms written in MATLAB and other various programming languages are freely available for download from the Textbook Companion Website.
- Community-developed MATLAB codes, examples, tips, and other resources are freely available for download from MATLAB File Exchange.

The Course Learning Outcomes: After completion of the course, the student should be able to:

- Approximate functions and interpolate precise data using Taylor series and polynomials, polynomial approximations, and piecewise polynomial approximations.
- Fit the best curve in the least-squares sense for data exhibiting a significant degree of error or scatter.
- Approximate the derivatives and definite integrals of functions.
- Approximate the solutions to IVPs and BVPs of ODEs.
- Determine the region of absolute stability for one- and multi-step methods to solve IVPs of stiff ODEs.

The Pacing Schedule

Weeks	Sections	Topics
1-3	1.1, 3.1, 3.3-3.5	Taylor Polynomials and Series - Interpolation and the Lagrange Polynomial - Divided Differences - Hermite Interpolation - Cubic Spline Interpolation
Monday, Sep. 23, 2019: The National Day Holiday		
4-6	4.1-4.4, 4.7	Numerical Differentiation - Richardson's Extrapolation - Elements of Numerical Integration - Composite Numerical Integration - Gaussian Quadrature
Monday, Oct. 14, 2019, 07:00 pm, 4-106: Midterm Exam		
7-11	5.1-5.4, 5.6, 5.9, 5.11	The Elementary Theory of Initial-Value Problems - Euler's Method - Higher-Order Taylor Methods - Runge-Kutta Methods - Multistep Methods - Higher-Order Equations and Systems of Differential Equations - Stiff Differential Equations
12, 13	11.1, 11.3	The Linear Shooting Method - Finite-Difference Methods for Linear Problems
14, 15	8.1, 8.3, 8.4	Discrete Least Squares Approximation - Chebyshev Polynomials and Economization of Power Series - Rational Function Approximation
Sunday, Dec. 15, 2019, 03:30-04:45 pm: Normal Monday Class (Place: 4-100)		
Thursday, Dec. 26, 2019, 07:00 pm: Final Exam (Place: TBA)		

Table 1

The Course Grading Policy:

	Date	Time	Place	Materials	Percentage
Midterm Exam (Written)	14-10-2019	07:00 pm	4-106	Sections 1.1, 3.1, 3.3, 3.4, 3.5, 4.1, 4.2	30% (120 pts)
Final Exam (Written)	26-12-2019	07:00 pm	TBA	Comprehensive	40% (160 pts)

Homework	• The homework includes exercises on the theoretical topics taught in classes in addition to MATLAB assignments. • Any homework should be of a written type and not of a multiple-choice type. • While I encourage discussions and work in groups, you must be the sole author of all work turned in, including computer programs. • You should properly cite any outside sources you used. • You are expected to express your answers clearly with solid justifications. Stating the final answer to a question without any justifications shall attract ZERO mark. • Box your final answer(s) and important intermediate results. • Staple your notes together, (i.e. no paper clips, torn or folded corners) with the assignment cover page. • You must use MATLAB software for the programming assignment with the code clearly commented. It is your responsibility to make your programming assignment compile and run successfully on approved platforms. Partial or no credit will be given for code that does not run or compile. • Late homework will not be accepted. • Electronic submission of the homework through email is not allowed. • The average x (out of 120) of the homework grade should be in the interval [84, 90]. (that is, [70%, 75%] of the homework grade).	30% (120 pts)

Table 2

The conversion from the overall percent grades into the final letter grades is shown in Table 3 below.

Overall Percent Grade	Letter Grade
$\geq 90\%$	A+
[85%, 90%)	A
[80%, 85%)	B+
[75%, 80%)	B
[70%, 75%)	C+
[60%, 70%)	C
[55%, 60%)	D+
[50%, 55%)	D
$< 50\%$	F

Table 3: Mapping of the overall percent grades into the final letter grades.

The Course Passing Grade: A student must score at least 50% (200/400) to pass the course.

Upgrade Policy: The upgrade policy is applied when 3 points out of 400 are needed to get the next higher grade. For instance, the passing grade D starts at 200/400. If a student gets 199/400 or 198/400, then his grade will automatically upgrade to D. However, if a student gets 197/400, his grade will upgrade to D only if his final exam score is greater than or equal to 50% of the Final Exam grade; that is, 80/160.

Exam Questions: The questions of the exams are based on the examples, homework problems, and exercises in the textbook and lectures.

Exams Formula Sheets: Each exam will have a formula sheet when necessary that will aid students during the exams. Copies of the Formula Sheets will be available in the Blackboard for students to reference while studying. You should not print the Formula Sheet and bring the hard copy with you to the exam location; instead a copy of the Formula Sheet shall be provided to you together with the exam sheets on the exam day.

Cheating in Exams: Cheating or any attempt of cheating by use of illegal activities, techniques and forms of fraud will result in a grade of **F** in the course along with reporting the incident to the higher university administration. Cheating in exams includes (but is not limited to)

- Looking at the papers of other students.
- Talking to other students.
- Using mobiles or any other electronic devices.

Missing an Exam:

Midterm Exam: No make-up exam will be given under any circumstances. In case a student misses the Midterm Exam for a legitimate reason (such as medical emergencies), his grade for this exam will be determined based on his performance in the homework and the Final Exam.

Final Exam: If a student misses the Final Exam for a legitimate reason (such as medical emergencies), he will be given a make-up Final Exam.

Attendance: Students are expected to attend all lectures.

- If a student misses a class, he is responsible for any announcement made in that class.
- A student is considered absent if not in class 10 minutes after the class start time; yet he is permitted to enter and attend the remainder of the class.
- A student, who has a valid excuse for an absence, must present an officially authorized document to his instructor no later than a week before the date of the Final Exam; no excuses shall be accepted after that date.
- A DN grade will be awarded to any student who accumulates
    - 9 unexcused absences in lectures.
    - 12 excused and unexcused absences in lectures.

The Usage of Mobiles in Class: Please turn off all cell phones and other electronic communication devices (including internet access on laptops) and keep them off the desk during regular classes. Text/voice messaging, email, etc., during classes is strictly prohibited and is grounds for dismissal.

Academic Integrity: All KFUPM policies regarding ethics apply to this course. See the Undergraduate Bulletin on the webpage of the Registrar.

Further Important Notes:

- Proofs of theorems are out of the course scope.
- Calculators are allowed in all exams.
- The recommended versions of MATLAB to use in this course are MATLAB R2019b or MATLAB R2019a, which are the latest stable releases.

Tips on how to enhance your problem-solving skills:

- Make sure you understand the concepts and techniques of each section.
- Do all the homework assignments on time.
- Try always first to solve the problems on your own before reading the solution or asking for help.
- Practice more problems than those given in the homework assignments.
- If you find it difficult to solve a certain type of problems, you should try more problems of that type.
- Try to make good use of the office hours of your instructor.
- Last, but not least, consult your instructor whenever you feel you need help understanding a concept or solving a problem.