King Saud University **Mathematics Department**
Math-254 (NUMERICAL METHODS) summer semester (1438 H)

Note: The Contents of the course will be covered by the following sections:

CHAPTER 1: 1.2,1.3.
CHAPTER 2: 2.1,2.2,2.3,2.4,2.5,2.6,2.7,2.8.
CHAPTER 3: 3.1,3.2,3.3,3.4,3.5,3.6,3.7.
CHAPTER 4: 4.1,4.2,4.3.
CHAPTER 5: 5.1,5.2,5.3,5.5,5.6.
CHAPTER 6: 6.1,6.2,6.3,6.4.

Note: About the 10 marks we do as follows:

Two Quizzes (3+3) + **Computer Assignments** (2) + **Class Attendance** (2).

Note: Both quizzes, two computer assignments and class attendance should be taken in the tutorial classes by the tutorial teachers.

Note: TEXTBOOK: Introduction to Numerical Analysis using MATLAB
AUTHOR: Rizwan Butt

NAMES AND TOPICS OF THE CHAPTERS OF THE COURSE

Chapter 1: Introduction to Numerical Methods

Error analysis and sources of errors.

Chapter 2: Solution of Nonlinear Equations

The bisection method: How to apply it and to compute an error bound for the approximate solutions derived by the method.
The Newton's method: How to apply it and the analysis of its error.
The secant method: How to apply it.
The fixed point iterative method: How to formulate the function $g(x)$ which will satisfies the conditions of the Theorem 2.2, then apply the iterative scheme and the analysis of the error.
The rate of convergence of the iterative methods including the Newton's method.
The multiple root: How to define it and discuss the conditions under which the root is said to be **simple or multiple**. Here some attention should be given for the rate of the convergence of Newton's method for both the simple and the multiple roots. Also, the following first and second modified Newton's methods should be discussed:

$$x_{n+1} = x_n - \frac{mf(x_n)}{f'(x_n)}, \quad f'(x_n) \neq 0, \quad \text{for} \quad n = 0, 1, 2, \ldots$$

where m is the multiplicity of the multiple roots, and the other one is

$$x_{n+1} = x_n - \frac{f(x_n)f'(x_n)}{[f'(x_n)]^2 - f(x_n)f''(x_n)}, \quad \text{for} \quad n = 0, 1, 2, \ldots$$

The Newton's method for the nonlinear systems (only for two nonlinear equations).

Chapter 3 Systems of Linear Algebraic Equations

How to apply the Gaussian elimination method (without pivoting)(algorithmic approach) and also, discuss the partial pivoting. Give examples showing that the system has infinite number of solutions or no solution at all (singular matrix).
How to apply the iterative methods (Jacobi and Gauss-Seidel) to solve a linear system. The analysis of the error related to these methods (condition for convergence, diagonally dominant matrix ...). Also, how to compute an error bound for both methods.
Error in solving linear systems. Residual vector, condition number of a given matrix... etc. How to compute an upper bound for both absolute and relative errors. Here we must give the definitions of the vector and matrix norms (l_∞ norm only).

Chapter 4: Polynomial Interpolation and Approximation

How to construct the Lagrange polynomial which approximate a function $f(x)$ at an $(n+1)$ distinct numbers(not the uniqueness).

How to apply the divided differences to construct the Newton's polynomial (without discussing the forward or backward cases).
Error in polynomial interpolation: How to compute an error bound for any x value in the interval $[a, b]$ and a given $x = \overline{x} \in [a, b]$. Interpolation using spline functions(Linear Spline Only).

Chapter 5 Numerical Differentiation and Integration

How to derive the **first** and **second** order finite difference formulas for approximating the first and second derivatives of the function $f(x)$ at a point x_0 using Lagrange and Taylor polynomials (note that for the first derivative we study (Forward+Central+Backward) and for the second derivative we study only the central difference formula). How to apply these formulas including the estimation of an error bound (also, discuss the effect of error in function values).
How to derive the Trapezoidal and the Simpson rules, how to apply them and to compute the error bounds (for both single and composite formulas).

Chapter 6: Numerical Solution of Ordinary Differential Equations

How to use the Euler's method, the Taylor method of order n and the Runge Kutta method of order **Two** (only Modified Euler's method).

Computer Assignment: Write computer program of the following methods.

Newton's Divided Difference Interpolation Method. (Chapter 4).

Dates of Midterm and Final Examinations will be take place as follows:

First Mterm: (25 Marks) Second Mterm: (25 Marks) Final Exam: (40 Marks)

Note: All the tutorial teachers should handover the checked quizzes papers to the concern teachers and the marks of computer assignments together with marks of attendance.

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