The student is expected to be knowledgeable in the topics listed below. The references given at the end of this syllabus may be useful for the student in preparing for the exam.

Topics:

1. Numerical Differentiation and Integration -

a) Finite Difference Approximation - Forward, Centered, and Backward Finite Difference schemes for first to fourth-order derivatives with up to the 4th order error terms; Finite difference formula for evenly spaced spatial and time-series data.
b) Newton-Cotes formulae for integration: Simpson's rule, Trapezoidal rule, Romberg integration.

c) Gauss-Legendre quadrature rules up to the 4th order.

2. Interpolation

a) Divided differences.
b) Lagrange interpolation.

3. Nonlinear Systems of Equations

a) Newton-Raphson method.
b) Bisection method.
c) Modified Newton's method.

4. Linear Algebra

a) Elementary Matrix Operations.
b) Matrix Norms.
c) The rank of a matrix, determinant of a matrix.
d) Positive-definite matrices, orthogonal matrices, similarity transformations
e) Linear regression.
f) Direct methods for solving systems of equations: Gaussian elimination, LU decomposition, Cholesky factorization.
g) Iterative methods for solving systems of equations: Gauss-Seidel, Jacobi's method, and SOR.

5. Numerical Solutions of First-Order ODEs:

a) Single-step methods: Taylor Series Method, Euler methods (Forward, Backward and Modified), Runge-Kutta Methods, and Runge-Kutta-Fehlberg methods
b) Global, local and propagated errors of ODE solutions

References

1- Steven Chapra, Applied Numerical Methods with MATLAB for Engineers and Scientists, 5th Edition, 2023.

Further Reading

1- C. Pozrikidis. Numerical Computation in Science and Engineering, 2nd edition, Oxford University Press, 2008.
2- Joe D. Hoffman. Numerical Methods for Engineers and Scientists, 2nd edition, Taylor & Francis, 2001.