



**Office of Academic Affairs**  
**WKU Course Syllabus**

**Course Title:** Numerical Analysis

**Course Number:** MATH 3940

**Semester:** FALL 2021

**Course Meeting Time:** (Beijing Time)

04:00 PM to 05:15 PM, Monday & Wednesday W01

04:00 PM to 05:15 PM, Tuesday and Thursday for W02

**Course Location:**

MATH\*W01 GEH C305 | MATH2526\*W02 CBPM A406

**Instructor Details:**

Dr. Puneet Rana

Email: prana@kean.edu

**Course Description:** Solution of equations and systems of equations, analysis of errors in numerical methods, numerical differentiation and integration, approximation, interpolation, solutions of differential equations. Use of computers.

Pre-requisite/program: *CPS 2231* and *MATH 2416*

**Course Student Learning Outcomes:**

At the completion of the course students will demonstrate the ability to:

1. Account for numerical error in computational analysis, rates of convergence of algorithms, and recognize known difficulties associated with classical computational algorithms.
2. Approximate and interpolate data and functions and work with fundamental concepts in approximation.
3. Solve systems of linear equations numerically and solve nonlinear systems.
4. Appreciate the difference between iterative and direct methods of solution for linear and nonlinear equations.
5. Solve problems involving numerical integration and differentiation. Solve basic differential equations numerically.

### **Textbook Information:**

Textbook Title: Numerical Analysis, Tenth Edition, Burden, R. L., Douglas Faires, J., Burden, A.M. ISBN: (ISBN-13: 978-1-305-25366-7) Publisher: Cengage Learning

### **Supplemental Materials:**

- Elementary Numerical (Third Edition), Atkinson, K., Weimin, H., (ISBN 0-471-43337-3), John Wiley & Sons, Inc.
- An Introduction to Numerical Analysis, Suli, E., Mayers, F. D., (ISBN-13 978-0-521-81026-5), Version 2003. Cambridge University Press
- Elementary Numerical Analysis: An Algorithmic Approach, S.D. Conte & C. de Boor, (ISBN 0070662282, 9780070662285) Third edition,. 1981. McGraw-Hill.

### **Course Requirements:**

- A. Instructional Methods:** We will start classes from 31 Aug 2021 in online mode. Students can access course content, reading/resources, class discussions, assessments, feedback and communications during the course. This course is taught using fifteen-units schedule (45 Hours Lectures Plan).
- B. Attendance Policy:** Your instructor will record class attendance and will mark you absent if you arrive later than 15 minutes or leave the classroom 15 minutes or more prior to the end of session.
- C. Make-Up Test Policy:** Missed exams can be made up within one week of the actual in-class examination. However, you must contact your instructor to arrange the scheduling of the make-up test within 24 hours of the date of the test that you missed. If you are unable to contact your instructor, please have a reliable person do this on your behalf. **Valid documentation may be requested by your instructor.** Examples of valid documentation includes: illness (doctor's excuse); self-confinement at home or in the dormitory does not qualify, death in the immediate family (obituary or funeral announcement), or appearance in court (copy of court documents will suffice).
- D. Tentative Method of Evaluation**
- |    |                            |     |
|----|----------------------------|-----|
| a. | Assignments and Class Work | 30% |
| c. | Quizzes (Best 4 out of 5)  | 40% |
| d. | Final Exam                 | 30% |
- a. Assignments and Class Work:**
1. Assignment will be provided weekly or biweekly with a specific deadline after the lecture.
  2. You have to submit assignments in your handwriting on your notebook. It may be asked to upload on blackboard (Bb) as single PDF file (Size should not more than 3 MB).
  3. After uploading the assignment file, ensure again that you uploaded a correct file.  
**So, ensure before uploading and ensure after uploading!!**
  4. You have to complete all assignments in your notebook and submit your notebook to me in last week.
  5. **No grade for assignments after the deadline.**

- b. **Quizzes:** There will total 5 quizzes (Online and f2f) and best four quizzes will be considered for grading. The quizzes will cover syllabus of first 10 units and each quiz may be taken biweekly on the basis of two units.
- c. **Final Exam:** The final exam is scheduled during the last week of classes and will not be given earlier regardless of any reason. Final exam is **closed book**. This exam will be announced on blackboard or in-person. If any exam is missed for a valid reason, please refer to the Make-Up Test Policy for exact details about what you should do.

- E. **Grading Policy:** Each student is responsible for keeping a record of points earned on tests. **You will be responsible for assessing your performance throughout the course.** Your instructor is NOT responsible for furnishing you with reminders concerning your progress and how you are doing at regular intervals throughout the course. **However, you should contact your instructor any time you have questions about your grade.** Your grade will be calculated as follows:

**Percentage:**

93 and above	A	75-79	C+
90-92	A-	70-74	C
87-89	B+	60-69	D
84-86	B	<60	F
80-83	B-		

Borderline grades will be resolved by performance on Final Exam and evidence of effort made throughout the semester (attendance, class participations, completion of online homework etc.)

- F. **Use of Electronic devices:** Cell phones, texting, laptops, or any other electronic devices are prohibited during class. If there is a reason for them to be on, you must let the instructor know before the class starts.
- G. **Buddy Information:** In the event you miss a class, it is your responsibility to find out what you have missed. Please use the space provided below to record at least one of your classmates' contact information.

**Course Content:**

- I. Error Analysis (Unit 1)
  1. Round-off Errors and Computer Arithmetic
  2. Algorithm and Convergence
- II. Solutions of Equations in One Variable (Unit 2)
  1. The Bisection Method
  2. Fixed-Point Iteration
  3. Newton's Method and Its Extensions
  4. Error Analysis for Iterative Methods
  5. Accelerating Convergence
  6. Zeros of Polynomials and Muller's Method
- III. Interpolation and Polynomial Approximation (Unit 3)

1. Interpolation and the Lagrange Polynomial
2. Data Approximation and Neville's Method
3. Divided Differences
4. Hermite Interpolation
5. Cubic Spline Interpolation
6. Parametric Curves
- IV. Numerical Differentiation and Integration (Unit 4-5)
  1. Numerical Differentiation
  2. Richardson's Extrapolation
  3. Elements of Numerical Integration
  4. Composite Numerical Integration
  5. Romberg Integration
  6. Gaussian Quadrature
  7. Multiple Integrals
- V. Initial-Value Problems for Ordinary Differential Equations (Unit 6-7)
  1. The Elementary Theory of Initial-Value Problems
  2. Euler's Method
  3. Higher-Order Taylor Methods
  4. Runge-Kutta Methods
  5. Error Control and the Runge-Kutta-Fehlberg Method
  6. Multistep Methods
  7. Variable Step-Size Multistep Methods
  8. Extrapolation Methods
  9. Higher-Order Equations and Systems of Differential Equations
  10. Stiff Differential Equations
- VI. Direct Methods for Solving Linear System (Unit 8)
  1. Linear Systems of Equations
  2. Pivoting Strategies
  3. Linear Algebra and Matrix Inversion
  4. The Determinant of a Matrix
  5. Matrix Factorization
- VII. Iterative Techniques in Matrix Algebra (Unit 9)
  1. Norms of Vectors and Matrices
  2. Eigenvalues and Eigenvectors
  3. The Jacobi and Gauss-Siedel Iterative Techniques
  4. Relaxation Techniques for Solving Linear Systems
- VIII. Approximating Eigenvalues (Unit 10-11)
  1. Linear Algebra and Eigenvalues
  2. Orthogonal Matrices and Similarity Transformations
  3. The Power Method
  4. Householder's Method
  5. The QR Algorithm
  6. Singular Value Decomposition
- IX. Numerical Solutions of Nonlinear Systems of Equations (Unit 12-13)
  1. Fixed Points for Functions of Several Variables
  2. Newton's Method
  3. Quasi-Newton Methods
  4. Steepest Descent Techniques
  5. Homotopy and Continuation Methods
- X. Boundary-Value Problems for Ordinary Differential Equations (Unit 14-15)
  1. The Linear Shooting Method
  2. The Shooting Method for Nonlinear Problems
  3. Finite-Difference Methods for Linear Problems

4. Finite-Difference Methods for Nonlinear Problems
5. The Rayleigh-Ritz Method

**Tentative Topics: in 15-week schedule, we will cover the following 15 units.**

*\* Your instructor reserves the right to change this schedule as needed.*

Unit 1	Unit 1: Error Analysis Readings: Sections 1.2-1.3 Resources: (1) <a href="https://ece.uwaterloo.ca/~dwharder/NumericalAnalysis/01Error/PrecisionAccuracy/">https://ece.uwaterloo.ca/~dwharder/NumericalAnalysis/01Error/PrecisionAccuracy/</a> (2) <a href="https://ece.uwaterloo.ca/~dwharder/NumericalAnalysis/01Error/Error/">https://ece.uwaterloo.ca/~dwharder/NumericalAnalysis/01Error/Error/</a> (3) <a href="https://ece.uwaterloo.ca/~dwharder/NumericalAnalysis/01Error/SignificantDigits/">https://ece.uwaterloo.ca/~dwharder/NumericalAnalysis/01Error/SignificantDigits/</a>
Unit 2	Unit 2: Solutions of Equations in One Variable Readings: Sections 2.1-2.6 Resources: (1) <a href="https://www.youtube.com/embed/OzFuihxtbtA">https://www.youtube.com/embed/OzFuihxtbtA</a> (2) <a href="https://www.youtube.com/embed/OLqdJMjib8">https://www.youtube.com/embed/OLqdJMjib8</a> (3) <a href="https://www.youtube.com/embed/ER5B_YBFMJJo">https://www.youtube.com/embed/ER5B_YBFMJJo</a> (4) <a href="https://www.youtube.com/embed/_MfjXOLUnyw">https://www.youtube.com/embed/_MfjXOLUnyw</a> (5) <a href="https://ece.uwaterloo.ca/~dwharder/NumericalAnalysis/10RootFinding/mueller/examples.html">https://ece.uwaterloo.ca/~dwharder/NumericalAnalysis/10RootFinding/mueller/examples.html</a> !
Unit 3	Unit 3: Interpolation and Polynomial Approximation Readings: Sections 3.1-3.6 Resources: (1) <a href="https://www.youtube.com/embed/GtJKUIG9KXI">https://www.youtube.com/embed/GtJKUIG9KXI</a> (2) <a href="https://www.youtube.com/embed/c_m5mElHLEg">https://www.youtube.com/embed/c_m5mElHLEg</a> (3) <a href="https://www.youtube.com/embed/EyRQXA56asI">https://www.youtube.com/embed/EyRQXA56asI</a> (4) <a href="https://www.youtube.com/embed/f9s6p9f-v1g">https://www.youtube.com/embed/f9s6p9f-v1g</a> (5) <a href="https://www.youtube.com/embed/f4iNbNRKZKU">https://www.youtube.com/embed/f4iNbNRKZKU</a>
Unit 4	Unit 4: Numerical Differentiation and Integration I Readings: Sections 4.1-4.5 Resources: (1) <a href="https://www.youtube.com/embed/stJ0rYor-kA">https://www.youtube.com/embed/stJ0rYor-kA</a> (2) <a href="https://www.youtube.com/embed/JGeCLfLaKMw">https://www.youtube.com/embed/JGeCLfLaKMw</a>
Unit 5	Unit 5: Numerical Differentiation and Integration II Readings: Sections 4.6-4.7 Resources: (1) <a href="https://www.youtube.com/embed/L05caullMZc">https://www.youtube.com/embed/L05caullMZc</a>
Unit 6	Unit 6: Initial-Value Problems for Ordinary Differential Equations I Readings: Sections 5.1-5.5 Resources: (1) <a href="https://www.youtube.com/watch?v=n1VrOBZepvw">https://www.youtube.com/watch?v=n1VrOBZepvw</a> (2) <a href="https://www.youtube.com/watch?v=QQFIWwDA9NM">https://www.youtube.com/watch?v=QQFIWwDA9NM</a>
Unit 7	Unit 7: Initial-Value Problems for Ordinary Differential Equations II Readings: Sections 5.6-5.11 Resources: (1) <a href="https://www.youtube.com/watch?v=clgn3JCPyOA">https://www.youtube.com/watch?v=clgn3JCPyOA</a> (2) <a href="https://www.youtube.com/watch?v=63FOdNNqPRM">https://www.youtube.com/watch?v=63FOdNNqPRM</a>
Unit 8	Unit 8: Direct Methods for Solving Linear System Readings: Sections 6.1-6.5 Resources: (1) <a href="https://www.youtube.com/watch?v=mMnGISw5Y94">https://www.youtube.com/watch?v=mMnGISw5Y94</a>

Unit 9	Unit 9: Iterative Techniques in Matrix Algebra Readings: Sections 7.1-7.4 Resources: (1) <a href="https://www.youtube.com/watch?v=hUvT4Xna1OQ">https://www.youtube.com/watch?v=hUvT4Xna1OQ</a> (2) <a href="https://www.youtube.com/watch?v=dx5EO4CKy54">https://www.youtube.com/watch?v=dx5EO4CKy54</a>
Unit 10	Unit 10: Approximating Eigenvalues I Readings: Sections 9.1-9.4 Resources: (1) <a href="https://www.youtube.com/watch?v=lz6pFK0AWIQ">https://www.youtube.com/watch?v=lz6pFK0AWIQ</a> (2) <a href="https://www.youtube.com/watch?v=J-BCvUALQyQ">https://www.youtube.com/watch?v=J-BCvUALQyQ</a> (3) <a href="https://www.youtube.com/watch?v=38P6LGNXXsk">https://www.youtube.com/watch?v=38P6LGNXXsk</a>
Unit 11	Unit 11: Approximating Eigenvalues II Readings: Sections 9.5-9.6 Resources: (1) <a href="https://www.youtube.com/watch?v=b3lnlQusF7k">https://www.youtube.com/watch?v=b3lnlQusF7k</a> (2) <a href="https://www.youtube.com/watch?v=9quic27dgcY">https://www.youtube.com/watch?v=9quic27dgcY</a>
Unit 12	Unit 12: Numerical Solutions of Nonlinear Systems of Equations I Readings: Sections 10.1-10.3 Resources: (1) <a href="https://www.youtube.com/watch?v=Qol3hJn-TRM">https://www.youtube.com/watch?v=Qol3hJn-TRM</a> (2) <a href="https://www.youtube.com/watch?v=KPEOBATCU54">https://www.youtube.com/watch?v=KPEOBATCU54</a>
Unit 13	Unit 13: Numerical Solutions of Nonlinear Systems of Equations II Readings: Sections 10.4-10.5 Resources: (1) <a href="https://www.youtube.com/watch?v=p8fVpPjRTsA">https://www.youtube.com/watch?v=p8fVpPjRTsA</a> (2) <a href="https://www.youtube.com/watch?v=aqHosRSkZ98">https://www.youtube.com/watch?v=aqHosRSkZ98</a>
Unit 14	Unit 14: Boundary-Value Problems for Ordinary Differential Equations I Readings: Sections 11.1-11.3 Resources: (1) <a href="https://www.youtube.com/watch?v=qlfxydBEdzg">https://www.youtube.com/watch?v=qlfxydBEdzg</a> (2) <a href="https://www.youtube.com/watch?v=NXel87Do0bA">https://www.youtube.com/watch?v=NXel87Do0bA</a> (3) <a href="https://www.youtube.com/watch?v=epBjRa9Cq0g">https://www.youtube.com/watch?v=epBjRa9Cq0g</a>
Unit 15	Unit 15: Boundary-Value Problems for Ordinary Differential Equations II Readings: Sections 11.3-11.5 Resources: (1) <a href="https://www.youtube.com/watch?v=Z_dITHOvgOo">https://www.youtube.com/watch?v=Z_dITHOvgOo</a>

Each student is responsible for reading and understanding the contents of:

**Important Dates:** Please check the academic calendar on the Kean Website

<http://www.wku.edu.cn/en/academics/academics-calendar/> for other important dates, or inquire with the Registrar's Office.

**Important University Policies and Information:** Students are responsible to review and understand the University Academic Integrity Policy (available at the Center for Academic Success or at <http://www.kean.edu/admin/uploads/pdf/AcademicIntegrityPolicy.pdf>)

Students should review the Student Code of Conduct, as it discusses expectations of appropriate conduct in the classroom: <http://www.kean.edu/KU/Code-of-Conduct>.

The Students Rights and Responsibilities handbook is available at:

<http://www.kean.edu/KU/Forms-Policies-and-Publications>

Students are strongly encouraged to register for the University's emergency notification system ([www.mir3.com/kean](http://www.mir3.com/kean)) in order to be informed of campus emergencies, weather notices, and other announcements.

All students must have a valid Kean email account. For those who do not already have one, forms are available on-line at <http://www.kean.edu/KU/Forms-OCIS>; click on E-mail Account Request Form.