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| A picture containing diagram  Description automatically generated | **AMERICAN INTERNATIONAL UNIVERSITY-BANGLADESH (AIUB)**  Faculty of Science and Technology (FST)  Department of Mathematics  Undergraduate Program |



I. Course Core and Title

MAT-3101: **Numerical Methods for Science and Engineering.**

II. Credit

**3 credit hours (3 hours of theory per week)**

III. Nature

**Core Course for CS and Engineering**

IV. Prerequisite

MAT 2202: **Matrices, Vectors and Fourier Analysis**

**V. Vision:**

Our vision is to be the preeminent Department of Mathematics through creating recognized professionals who will provide innovative solutions by leveraging contemporary research methods and development techniques of computing that is in line with the national and global context.

**VI. Mission:**

The mission of the Department of Mathematics of AIUB is to educate students in a student-centric dynamic learning environment; to provide advanced facilities for conducting innovative research and development to meet the challenges of the modern era of computing, and to motivate them towards a life-long learning process.

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| **COURSE PLAN** | **Fall: 2023-2024** |



## **VII - Course Description:**

* + Introduce commands, built in functions in MATLAB and necessary in real life to solve problems.
  + Discussion about equations in one variable, System of linear, nonlinear equations and introduce useful numerical methods to solve them.
  + Discussion about Spline Interpolation to observing behavior of functions.
  + Explanation about Interpolation and curve fitting with useful numerical methods.
  + Discussion about Numerical Differentiation and Numerical Integration with applications in real life problems.
  + Discussion about ODE (Ordinary Differential Equations) with IVP (Initial value problem) and BVP (Boundary value problem) and its applications in real life problems.

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## **VIII - Course outcomes (CO) Matrix:**

By the end of this course, students should be able to:

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| **COs**\* | **CO Description** | Level of Domain\*\*\* | | | PO Assessed \*\*\*\* | |
| C | P | A |
| CO1 | Understand fundamental concepts of MATLAB, solve problems and write code by applying commands, built in function(s) in MATLAB. | 3 |  |  | PO-a-2 | |
| **CO2 \*\*** | ***Solve equation in one variable, system of linear and nonlinear equations.*** | ***4*** |  |  | ***PO-b-2*** | |
| **CO3**  **\*\*** | ***Solve the ODE(s) including IVP & BVP by applying numerical methods.*** | ***4*** |  |  | ***PO-b-2*** | |
| CO4 | Analyze data sets and observe behavior of functions by applying Mathematical operations. | 4 |  |  | PO-b-2 | |
| *C: Cognitive; P: Psychomotor; A: Affective Domain*  *\* CO assessment method and rubric of COs assessment is provided in later section*  *\*\* COs will be mapped with the Program Outcomes (POs) for PO attainment \*\*\* The numbers under the ‘Level of Domain’ columns represent the level of Bloom’s Taxonomy each   CO corresponds to.*  *\*\*\*\* The numbers under ‘PO Assessed’ column represent the POs each CO corresponds to.* | | | | | |

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## **IX - Topics to be covered in the class and/or lab: \***

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| **Time Frame** | **CO**  **Mapped** | **Topics** | **Teaching**  **Activities** | **Assessment Strategy(s)** |
| **Week 1** | **CO1, CO2** | **Representation of numbers & errors:** Decimal places, Significant figures. Rounding. Error estimation. Short introduction of MATLAB (numerical and symbolic) | Lecture delivery, Board work, Solving exercises, Discussion | Lecture notes, question-answer session |
| **Week 2** | **CO1, CO2** | **Systems of linear equations:** Gaussian elimination with pivoting. Iterative methods (Jacobi and Gauss-Seidel) of solution. Solutions using MATLAB commands. | Lecture delivery, Board work, Solving exercises, Discussion | Quiz 1, Lecture notes, question-answer session |
| **Week 3** | **CO1, CO2** | **Solution of Equations in one variable:** Number of roots by graphical method, Secant Method, Newton’s and Fixed point iteration methods. | Lecture delivery, Board work, Solving exercises, Discussion | Lecture notes, question-answer session |
| **Week 4** | **CO1, CO2** | **Solutions of nonlinear system:** Newton’s method & fixed point iteration method.  Solutions using MATLAB command | Lecture delivery, Board work, Solving exercises, Discussion | Lecture notes, question-answer session |
| **Week 5** | **CO1, CO4** | **Interpolation:** Finite differences and shift operators. Polynomial approximation. Newton’s forward, backward and divided difference formulae. Lagrange form. | Lecture delivery, Board work, Solving exercises, Discussion | Quiz 2, Lecture notes, question-answer session. |
| **Week 6** | **CO1, CO4** | **Curve fitting:** Interpolation using a fixed curve. Least square method. | Lecture delivery, Board work, Solving exercises, Discussion | Lecture Notes, question-answer session. |
| **Week 7** | **CO1, CO4** | **Spline interpolation:** Linear spline (using equation of line through 2 points), quadratic and cubic splines.  Solutions using MATLAB commands | Lecture delivery, Board work, Solving exercises, Discussion | Quiz 3, Lecture Notes, question-answer session. |
| **Midterm (Week 8)** | | | | |
| **Week 9** | **CO1, CO4** | **Numerical Differentiation:** Forward, backward, and central difference formulae for derivatives,  Richardson’s extrapolation | Lecture delivery, Board work, Solving exercises, Discussion | Lecture  Notes, question-answer session. |
| **Week 10** | **CO1, CO2** | **Numerical Integration:** Introduction. Newton- Cotes quadrature rules. Composite trapezoidal and Simpson’s rules. | Lecture delivery, Board work, Solving exercises, Discussion | Lecture  Notes, question-answer session. |
| **Week 11** | **CO1, CO2** | **Numerical Integration:** Romberg integration. Double Integration. Gaussian quadrature rule | Lecture delivery, Board work, Solving exercises, Discussion | Quiz 1, Lecture Notes, question-answer session. |
| **Week 12** | **CO1, CO3** | **Ordinary Differential Equations (ODEs) and System of ODEs:** Taylor series solution. Euler’s and modified Euler’s method. The Runge- Kutta methods (RK-2 and RK-4 methods). | Lecture delivery, Board work, Solving exercises, Discussion. | Lecture  Notes, question-answer session. |
| **Week 13** | **CO1, CO3** | **Ordinary Differential Equations (ODEs) and System of ODEs:** The Runge- Kutta methods (RK-2 and RK-4 methods). | Lecture delivery, Board work, Solving exercises, Discussion. | Quiz 2, Lecture  Notes, question-answer session. |
| **Week 14** | **CO1, CO3** | Solution of ODE by finite difference method (initial & boundary value problems). | Lecture delivery, Board work, Solving exercises, Discussion | Lecture Notes, question-answer session. |
| **Week 15** | **CO1, CO3** | **Approximating Eigenvalues:** The power method, The inverse power method. | Lecture delivery, Board work, Solving exercises, Discussion | Quiz 3, Lecture Notes, question-answer session. |
| Final term (Week 16) | | | | |
| Project & Presentation (Week 17) | | | | |

*\* The faculty reserves the right to change, amend, add, or delete any of the contents.*



## **X - Mapping of PO to Courses and K, P, A**

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| PO Indicator ID | PO Indicators Definition (As per the requirement of WKs) | Domain | K | P | A |
| PO-a-2 | Apply information and concepts of *mathematics* with the familiarity of issues. | Cognitive Level 3 (Applying) | 2 |  |  |
| PO-b-2 | Formulate solutions, procedures, and methods using first principles of mathematics for engineering sciences. | Cognitive Level 4 (Analyzing) | 2 |  |  |



## **XI – K, P, A Definitions**

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| **Indicator** | **Title** | **Description** |
| **K2** | Conceptual based mathematics | Conceptually based mathematics, numerical analysis, statistics and the formal aspects of computer and information science to support analysis and modeling applicable to the discipline |



## **XII – Mapping of CO Assessment Method and Rubric**

The mapping between Course Outcome(s) (COs) and The Selected Assessment method(s) and the mapping between Assessment method(s) and Evaluation Rubric(s) is shown below:

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| **COs** | **Description** | **Mapped**  **POs** | **Assessment Method** | **Assessment Rubric** |
| **CO1** | Understand fundamental concepts of MATLAB, Solve problems and write code by applying commands, built in function(s) in MATLAB. | PO-a-2 | Quiz/ Term Question & Assignment | Rubric for Quiz/ Term Question & Assignment |
| **CO2** | Solve equation in one variable, system of linear and nonlinear equations. | PO-b-2 | Quiz/ Term Question & Assignment | Rubric for Quiz/ Term Question & Assignment |
| **CO3** | Solve the ODE(s) including IVP & BVP by applying numerical methods. | PO-b-2 | Quiz/ Term Question & Assignment | Rubric for Quiz/ Term Question & Assignment |
| **CO4** | Analyze data sets and observe behavior of functions by applying Mathematical operations. | PO-b-2 | Quiz/ Term Question & Assignment | Rubric for Quiz/ Term Question & Assignment |

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## **XIII – Evaluation and Assessment Criteria**

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| **CO1:** Understand fundamental concepts of MATLAB, Solve problems and write code by applying commands, built in function(s) in MATLAB. | | | | | |
| **Assessment Criteria** | **Not Attended/ Incorrect (0)** | **Inadequate  (1-2)** | **Average (3)** | **Good  (4)** | **Excellent (5)** |
| **Evaluation Criteria** | **Evaluation Definition** | | | | |
| Definition | Definition provided with the relevance to the subject matter. Correctly define the terms. | | | | |
| Evaluation | Fundamental concepts of descriptive Numerical Methods. Student identifies the appropriate necessary methods and MATLAB code. | | | | |
| Correctness of answer | Arrived at correct answer, showing every step of MATLAB command. | | | | |

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| **CO2:** Solve equation in one variable, system of linear and nonlinear equations. | | | | | |
| **Assessment Criteria** | **Not Attended/ Incorrect (0)** | **Inadequate  (1-2)** | **Average (3)** | **Good  (4)** | **Excellent (5)** |
| **Evaluation Criteria** | **Evaluation Definition** | | | | |
| Definition | Classify the problem with the relevant methods. | | | | |
| Evaluation | Solve the problems applying appropriate method showing necessary steps of calculations. | | | | |
| Correctness of answer | Analyze the error with existing numerical data and come to a conclusion. | | | | |

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| **CO3:** Solve the ODE(s) including IVP & BVP by applying numerical methods. | | | | | |
| **Assessment Criteria** | **Not Attended/ Incorrect (0)** | **Inadequate  (1-2)** | **Average (3)** | **Good  (4)** | **Excellent (5)** |
| **Evaluation Criteria** | **Evaluation Definition** | | | | |
| Definition | Classify the problem with the relevant methods. | | | | |
| Evaluation | Solve the problems applying appropriate method showing necessary steps of calculations. | | | | |
| Correctness of answer | Analyze the error with existing numerical data and come to a conclusion. | | | | |

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| **CO4:** Analyze data sets and observe behavior of functions by applying Mathematical operations. | | | | | |
| **Assessment Criteria** | **Not Attended/ Incorrect (0)** | **Inadequate  (1-2)** | **Average (3)** | **Good  (4)** | **Excellent (5)** |
| **Evaluation Criteria** | **Evaluation Definition** | | | | |
| Definition | Classify the problem with the relevant methods. | | | | |
| Evaluation | Solve the problems applying appropriate method showing necessary steps of calculations. | | | | |
| Correctness of answer | Analyze the error with existing numerical data and come to a conclusion. | | | | |

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## **XIV- Course Requirements**

* Students are expected to attend at least 80% class.
* Students are expected to participate actively in the class.
* For both terms, there will be at least 2 quizzes based on the theoretical knowledge and conceptual understanding of the topic covered discussed in the classes.

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## **XV – Evaluation & Grading System\***

The following grading system will be strictly followed in this class

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| **MID TERM** | | **FINAL TERM** | |
| Attendance | 10% | Attendance | 10% |
| Performance | 10% | Performance | 10% |
| Quiz | 40% | Quiz | 40% |
| Midterm written exam | 40% | Final term written exam | 40% |
| Total | 100% | Total | 100% |
| **Grand Total 100% = 40% of Midterm + 60% of Final Term** | | | |

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| **Letter** | **Grade Point** | **Numerical %** |
| A+ | 4.00 | 90-100 |
| A | 3.75 | 85 - < 90 |
| B+ | 3.50 | 80 - < 85 |
| B | 3.25 | 75 - < 80 |
| C+ | 3.00 | 70 - < 75 |
| C | 2.75 | 65 - < 70 |
| D+ | 2.50 | 60 - < 65 |
| D | 2.25 | 50 - < 60 |
| F | 0.00 | < 50 |
| I |  | Incomplete |
| W |  | Withdrawal |
| UW |  | Unofficially Withdrawal |

*\* The evaluation system will be strictly followed as par the AIUB grading policy.*

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## **XVI – Textbook/ References**

1. Numerical Methods for Engineers and Scientists -Amos Gilat, Vish Subramaniam, 3rd Edition.
2. Numerical Methods in Engineering with MATLAB – Jaan Kiusalaas, 4th Edition, 2018, [CAMBRIDGE UNIVERSITY PRESS](https://www.bookdepository.com/publishers/CAMBRIDGE-UNIVERSITY-PRESS), UK.
3. Applied Numerical Analysis – C.F.Gerald & P.O.Wheatley, 7th Edition, 2003, [Pearson Education Limited](https://www.bookdepository.com/publishers/Pearson-Education-Limited), USA
4. Numerical Analysis & Computing – W. Cheney & D. Kincaid, 6th Edition, 2007, [Cengage Learning, Inc,](https://www.bookdepository.com/publishers/Cengage-Learning-Inc) USA.
5. Numerical Analysis – [J. Douglas Faires ,](https://www.bookdepository.com/author/J-Douglas-Faires)  [Annette Burden ,](https://www.bookdepository.com/author/Annette-Burden)  [Richard Burden](https://www.bookdepository.com/author/Richard-Burden), 10th Edition, 2015, [Cengage Learning, Inc,](https://www.bookdepository.com/publishers/Cengage-Learning-Inc) USA.

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## **XVII - List of Faculties Teaching the Course**

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| **FACULTY NAME** | **SIGNATURE** |
| Dr. Mohammed Mostafizur Rahman |  |
| Prodip Kumar Ghose |  |
| Mahadeb Kumar Das |  |
| Santa Deb |  |
| Pronab Das |  |



## **XVI – Verification**

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| **Prepared by:**  ---------------------------------  **Pronab Das & Mahadeb Kumar Das**  *Lecturer,*  *Department of Mathematics*  Date:........................................ | **Moderated by:**  ---------------------------------  **Dr. M. Mostafizur Rahman**  *Head,*  *Department of Mathematics*  Date:......................................... | |
| **Checked by:**  ................................................  **Dr. Mohammad Mahmudul Hasan**  *Point of Contact*  *OBE Implementation Committee for CS*  Date:........................................ | **Certified by:**  ................................................  **Dr. Dip Nandi**  *Associate Dean*, *Faculty of Science & Technology*  Date:....................................... | **Approved by:**  ...............................................  **Mr. Mashiour Rahman**  *Dean*, *Faculty of Science & Technology*  Date:....................................... |