**COURSE DESCRIPTION FORM: MT-1008 Multivariable Calculus**

**INSTITUTION**  FAST School of Computing, National University of Computer and Emerging Sciences, Islamabad

BSAI, BSCY, BSSE, BSDS – **Spring 2025**

**PROGRAM TO BE EVALUATED**

**Course Description**

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| **Course Code** | MT-1008 | | | | | | | | | | | | | | | | | |
| **Course Title** | Multivariable Calculus | | | | | | | | | | | | | | | | | |
| **Credit Hours** | 3 | | | | | | | | | | | | | | | | | |
| **Course Instructors** | Dr. Muhammad Usman Ashraf , Dr. Sumaira Azhar , Dr. Irfan Shah , Mr. Muhammad Adnan | | | | | | | | | | | | | | | | | |
| **Prerequisites by Course(s) and Topics** | MT-1003 | | | | | | | | | | | | | | | | | |
| **Grading Policy** | Absolute Grading | | | | | | | | | | | | | | | | | |
| **Policy about missed and late assessment items in the course** | Retake of missed assessment items (other than sessional / final exam) will not be held. A student who misses an assessment item (other than sessional / final exam) is awarded zero marks in that assessment item, i.e., late submission will not be accepted.  For the missed sessional / final exam, exam retake/ pre-take application along with necessary evidence are required to be submitted to the department secretary. The examination assessment and retake committee will decide the exam retake/ pre-take cases. | | | | | | | | | | | | | | | | | |
| **Course Plagiarism Policy** | Plagiarism in projects or midterm/ final exam may result in an F grade in the course. Plagiarism in an assessment item will result in zero marks in the respective assessment category. The case will be forwarded to the disciplinary committee as well. | | | | | | | | | | | | | | | | | |
| **Assessment Instruments with Weights** (homework, quizzes, midterms, final, programming assignments, lab work, etc.) | 100% Theory Assessment items   |  |  |  | | --- | --- | --- | | **Assessment Item** | **Number** | **Weight (%)** | | Assignments | 4-6 | 10 | | Quiz | 6-8 | 10 | | Sessional I | 1 | 15 | | Sessional II | 1 | 15 | | Project | 1 | 05 | | Final Exam | 1 | 45 | | | | | | | | | | | | | | | | | | |
| **Course Coordinator** | **Dr. M. Usman Ashraf (BSAI ) , Dr. Sumaira Azhar (BSSE) , Dr. Irfan Shah ( BSDS & BSCY )** | | | | | | | | | | | | | | | | | |
| **URL (if any)** | - | | | | | | | | | | | | | | | | | |
| **Current Catalog Description** | Multivariable functions, Limit and continuity in higher dimensions, Partial derivatives, Chain rule, Directional Derivatives and Gradient Vectors, Applications of Gradient, Eq of lines and planes,Tangent Planes and Normal Lines, Linearization, Extreme values and their applications, Constrained Maxima and Minima, Lagrange Multipliers, Automatic Differentiation, Computational Graph, Double integrals over rectangular and general regions, Area by double integration, Double integral in polar form, Triple integrals, Applications of Multiple Integrals, Line Integrals, Vector Fields, Gradient Fields, Path Independence, Conservative Fields, Line Integral in Conservative Fields, Potential Functions, Divergence, Parametrizations of Surfaces, Surface Area, Surface Integrals, Surface Integrals of Scalar Functions, Surface Integrals of Vector Fields, The Curl Vector Field, Divergence in Three Dimensions, Divergence Theorem. | | | | | | | | | | | | | | | | | |
| **Textbook** | 1. Thomas’ Calculus, Early Transcendentals 13th ed., by George B. Thomas Jr, Maurice D. Weir and Joel Hass, Pearson. 2. Calculus by Larson, Hostetler, and Edwards, 8th ed. | | | | | | | | | | | | | | | | | |
| **Reference Material** | 1. Calculus (9th Edition or latest) by James Stewart. 2. Learning Scientific Programming with Python, Christian Hill, University College London. | | | | | | | | | | | | | | | | | |
| **Course Goals** | **A. Course Learning Outcomes (CLOs) (Cognitive Level) (PLO Mapping)** | | | | | | | | | | | | | | | | | |
| After completion of the course, the students shall be able to:   1. Understand the basic concepts and terminologies of multivariable functions. (C2)(PLO3) 2. Apply appropriate techniques to solve real world problems of multivariable functions. (C3)(PLO3) | | | | | | | | | | | | | | | | | |
| **B. Program Learning Outcomes (Covered attribute is indicated with a tick (**✔**) mark)** | | | | | | | | | | | | | | | | | |
| **PLO 1** | | Academic Education | | | | | Completion of an accredited program of study designed to prepare graduates as computing professionals | | | | | | | | | |  |
| **PLO 2** | | Knowledge for Solving Computing Problems | | | | | Apply knowledge of computing fundamentals, knowledge of a computing specialization, and mathematics, science, and domain knowledge appropriate for the computing specialization to the abstraction and conceptualization of computing models from defined problems and requirements | | | | | | | | | |  |
| **PLO 3** | | Problem Analysis | | | | | Identify, formulate, research literature, and solve complex computing problems reaching substantiated conclusions using fundamental principles of mathematics, computing sciences, and relevant domain disciplines | | | | | | | | | | ✔ |
| **PLO 4** | | Design/ Development of Solutions | | | | | Design and evaluate solutions for complex computing problems, and design and evaluate systems, components, or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations | | | | | | | | | |  |
| **PLO 5** | | Modern Tool Usage | | | | | Create, select, adapt and apply appropriate techniques, resources, and modern computing tools to complex computing activities, with an understanding of the limitations | | | | | | | | | |  |
| **PLO 6** | | Individual and Team Work | | | | | Function effectively as an individual and as a member or leader in diverse teams and in multi-disciplinary settings | | | | | | | | | |  |
| **PLO 7** | | Communication | | | | | Communicate effectively with the computing community and with society at large about complex computing activities by being able to comprehend and write effective reports, design documentation, make effective presentations, and give and understand clear instructions | | | | | | | | | |  |
| **PLO 8** | | Computing Professionalism and Society | | | | | Understand and assess societal, health, safety, legal, and cultural issues within local and global contexts, and the consequential responsibilities relevant to professional computing practice | | | | | | | | | |  |
| **PLO 9** | | Ethics | | | | | Understand and commit to professional ethics, responsibilities, and norms of professional computing practice | | | | | | | | | |  |
| **PLO 10** | | Life-long Learning | | | | | Recognize the need, and have the ability, to engage in independent learning for continual development as a computing professional | | | | | | | | | |  |
| **C. Mapping of CLOs on PLOs** | | | | | | | | | | | | | | | | | |
| **CLO PLO** | **1** | | **2** | | **3** | **4** | | **5** | | **6** | **7** | **8** | | **9** | | **10** | |
| **1** |  | |  | | **C2** |  | |  | |  |  |  | |  | |  | |
| **2** |  | |  | | **C3** |  | |  | |  |  |  | |  | |  | |
| **Topics covered in the course** | **Topics** | | | | | | | | | | | | | **No. of Weeks** | | **Contact Hours** | | **CLOs** |
| * Multivariable functions, Limit and continuity in higher dimensions, Partial derivatives, Chain Rule, Directional Derivatives and Gradient Vectors, Equation of lines and planes, Tangent Planes and Normal Lines, Linearization. | | | | | | | | | | | | | 3 | | 9 | | 1 |
| * Applications of Gradient, Extreme values and their applications, Constrained Maxima and Minima, Lagrange Multipliers, Applications of Constrained Optimization, Automatic Differentiation, Computational Graph. | | | | | | | | | | | | | 3 | | 9 | | 2 |
| * Double integrals over rectangular and general regions, Area by double integration, Double integrals in polar form, Triple integrals, Average value of function in space, Volume of a region in space. | | | | | | | | | | | | | 3.5 | | 10.5 | | 1 |
| * Applications of multiple integrals. | | | | | | | | | | | | | 0.5 | | 1.5 | | 2 |
| * Line Integrals, Vector Fields, Gradient Fields, Path Independence, Conservative Fields, Potential Functions, Divergence, Parametrizations of Surfaces. | | | | | | | | | | | | | 1.5 | | 4.5 | | 1 |
| * Line Integral in Conservative Fields, Surface Area, Surface Integrals, Surface Integrals of Scalar Functions. | | | | | | | | | | | | | 1.5 | | 4.5 | | 2 |
| * The Curl Vector Field, Divergence in Three Dimensions, Divergence Theorem. | | | | | | | | | | | | | 1.5 | | 4.5 | | 1 |
| * Surface Integrals of Vector Fields. | | | | | | | | | | | | | 0.5 | | 1.5 | | 2 |
| **Total** | | | | | | | | | | | | | **15** | | **45** | |  |
| **Programming Language for Assignments** | Python (Sympy, Scipy, Numpy) | | | | | | | | | | | | | | | | | |
| **Class Time Spent** (in hours – per week) | **Theory (%)** | | | | **Problem Analysis (%)** | | | | | **Solution Design (%)** | | | **Social and Ethical Issues (%)** | | | | | |
| 35 | | | | 30 | | | | | 30 | | | 5 | | | | | |
| **Oral and Written Communications** | Every student is required to submit \_01\_\_\_ written report of typically \_10\_ pages. | | | | | | | | | | | | | | | | | |

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| **Weeks** | **Contents/Topics** | **Courseware Events**  (Quiz/ Assignment/ Project) |
| **Week 01** | Function of Several Variables, Domain & Range,Open, Closed Regions, Bounded/Unbounded Regions, Graphs, Level Curves, Contours of Functions of Two variables, Ex 14.1. |  |
| **Week 02** | Limit, Path Test for Limit, Continuity, Continuity of composites, Ex 14.2, Partial Derivatives, Mixed derivatives, Differentiability, Ex 14.3,  Chain Rule. | Quiz # 1 |
| **Week 03** | Ex 14.4, Directional Derivatives and Gradient Vector, Applications of Gradient, Ex 14.5.Eq of lines and planes,Ex 12.5. | Assignment # 1  Quiz # 2 |
| **Week 04** | Tangent Planes and Normal Lines, Linearization, Ex 14.6, Extreme Values and Saddle Point, Tests of point classification such as Derivative Tests for Local Extreme Values. | Quiz # 3 |
| **Week 05** | Absolute Maxima and Minima on Closed Bounded Region, Ex 14.7, Constrained Maxima and Minima, Method of Lagrange Multipliers, Ex 14.8, Computational Graphs. | Assignment # 2  Quiz # 4 |
| **Week 06** | Automatic Differentiation, Revision of Sessional I topics. | **Sessional I** |
| **Week 07** | Recalling integration of function of one variable, Double Integrals over Rectangular Regions, Ex 15.1, Intro to nonrectangular regions. | Assignment # 3 |
| **Week 08** | Double Integrals Over Nonrectangular Regions, Ex 15.2, Area by double integration, Ex 15.3. | Quiz # 5 |
| **Week 09** | Intro to polar coordinates and polar curves, Double Integrals in Polar form, Changing Cartesian Integrals into Polar Integrals, Ex 15.4, Triple Integrals in Rectangular Coordinates, Average value of a function in space. | Assignment # 4  Quiz # 6 |
| **Week 10** | Ex 15.5, Volume of a Region in space, Applications of multiple integrals. | Quiz # 7 |
| **Week 11** | Vector Fields and their sketching, Conservative vector fields, Test for conservative vector fields, Potential function, Curl of a vector field, Divergence of a vector field, Ex 16.1. | Assignment # 5  **Sessional II** |
| **Week 12** | Piecewise smooth curves and its parametrization, Line integrals and its evaluation, Ex 16.2, Fundamental theorem of line integrals, Path Independence and Conservative Fields, Ex 16.3. | Project |
| **Week 13** | Parametrizations of Surfaces, Surface Area, Ex 16.5. | Quiz # 8 |
| **Week 14** | Surface Integrals, Surface Integrals of Scalar Functions, Surface Integrals of Vector Fields, Ex 16.6. |  |
| **Week 15** | Divergence in Three Dimensions, Divergence Theorem, Ex 16.8.  Revision. |  |

