COURSE DESCRIPTION FORM: [MT1008]: [Multivariable Calculus]

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

Computer Science (BSCS)-**Spring-2024**

PROGRAM(s) TO BE EVALUATED

Course Description

Course Code	MT-1008
Course Title	Multivariable Calculus
Credit Hours	3
Course Instructors	Dr. Sumaira Azhar
Grading Policy	Absolute
Policy about missed assessment items in the course	Retake of missed assessment items (other than sessional/ final exam) will not be held. 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 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 decide the exam retake/ pre-take cases.
Course Plagiarism Policy	Plagiarism in project or sessional/ final exam will result in F grade in the course. Plagiarism in an assignment will result in zero marks in the whole assignments category.
Prerequisites by Course(s) or Topics	Calculus and Analytical Geometry
Assessment Instruments with Weights (homework, quizzes, sessional exams, final exam, assignments, etc.)	Assessment with the weight.

Assessment Type	**Weight**
Grand Assignment	07
Quizzes (6-8)	8
Home works	05
Sessional I	15
Sessional II	15
Final Exam	50

Course Coordinator	
URL (if any)	-

Course Catalog Description	Multivariable functions, Limit and continuity in higher dimensions, Partial derivatives, Extreme values and their applications, Chain rule, Directional Derivatives and Gradient Vectors, Applications of Gradient, Tangent Planes and Normal Lines, Linearization, Constrained Maxima and Minima, Lagrange Multipliers, Double integrals over rectangular and general regions, Area by double integration, Double integral in polar form, Triple integrals, Automatic Differentiation, Computational Graph, 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(s)	Thomas Calculus, 13th ed., by George B. Thomas Jr, Maurice D. Weir and Joel Hass, Pearson.
Reference Material	1. Calculus (Sixth Edition) By Swokowski. 2. Learning Scientific Programming with Python, Christian Hill, University College London.
Course Goals	

A. Course Learning Outcomes (CLOs)

After completion of the course, the student shall be able to:

1. Understand the basic concepts associated with Calculus problems in several variables.
2. Apply appropriate techniques for solving problems in several variables including differentiation, double and triple integrals.
3. Adapt modern programming languages and computing tools to apply appropriate mathematical techniques on real life problems.
4. Organize and prioritize work effectively as an individual or as a member/leader of a technical team.

B. Program Learning Outcomes (PLOs)

PLO 1	Computing Knowledge	Apply knowledge of mathematics, natural sciences, computing fundamentals, and a computing specialization to the solution of complex computing problems.	✔
PLO 2	Problem Analysis	Identify, formulate, research literature, and analyze complex computing problems, reaching substantiated conclusions using first principles of mathematics, natural sciences, and computing sciences.	
PLO 3	Design/ Develop Solutions	Design solutions for complex computing problems and design systems, components, and processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations.	✔
PLO 4	Investigation & Experimentation	Conduct investigation of complex computing problems using research based knowledge and research based methods.	
PLO 5	Modern Tool Usage	Create, select, and apply appropriate techniques, resources and modern computing tools, including prediction and modelling for complex computing problems.	✔

PLO 6	Society Responsibility	Apply reasoning informed by contextual knowledge to assess societal, health, safety, legal, and cultural issues relevant to context of complex computing problems.	
PLO 7	Environment and Sustainability	Understand and evaluate sustainability and impact of professional computing work in the solution of complex computing problems.	
PLO 8	Ethics	Apply ethical principles and commit to professional ethics and responsibilities and norms of computing practice.	
PLO 9	Individual and Teamwork	Function effectively as an individual, and as a member or leader in diverse teams and in multi-disciplinary settings.	✔
PLO 10	Communication	Communicate effectively on complex computing activities with the computing community and with society at large.	
PLO 11	Project Management and Finance	Demonstrate knowledge and understanding of management principles and economic decision making and apply these to one's own work as a member or a team.	
PLO 12	Life Long Learning	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological changes.	

C. Mapping of CLOs to PLOs
(CLO: Course Learning Outcome, PLOs: Program Learning Outcomes)

		PLOs											
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
CLOs	1	✔											
	2			✔									
	3					✔							
	4									✔			

Topics covered in the course
(assume 16-week instruction and 3 contact hours per week)

Topics to be covered:

List of Topics	No. of Weeks	Contact Hours	CLO(s)
Multivariable functions, Limit and continuity in higher dimensions, Partial derivatives, Extreme values and their applications, Chain Rule, Directional Derivatives and Gradient Vectors, Applications of Gradient, Tangent Planes	6	18	1,2,3,4

	and Normal Lines, Linearization, Constrained Maxima and Minima, Lagrange Multipliers, Applications of Constrained Optimization. Use of modern tools / technology: 3D plot, calculating the partial derivative, gradient, finding extrema of multivariable function.			
	Double integrals over rectangular and general regions, Area by double integration, Double integrals in polar form, Triple integrals, Applications of multiple integrals, Automatic Differentiation. Use of modern tools / technology: calculating the integrals of multivariable functions	4	12	1,2,3,4
	Computational Graph, 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. Use of modern tools / technology: Use of Numpy for surface integrals, Visualize divergence fields with Matplotlib, Compute gradients using NumPy.	3	9	1,2,3,4
	Surface Integrals of Vector Fields, The Curl Vector Field, Divergence in Three Dimensions, Divergence Theorem. Use of modern tools / technology: Use NumPy to compute the curl and divergence of a vector field.	2	6	1,2,3,4
	Total	**15**	**45**	

Programming Language for Assignments (if any)	Python (Sympy, Scipy, Numpy)			
Class Time Spent (in percentage)	**Theory**	**Problem Analysis**	**Solution Design**	**Social and Ethical Issues**
	35	30	30	5
Oral and Written Communications	Every student is required to submit at least 01 written report of typically 10-12 pages.			

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, Ex 14.2, Partial Derivatives, Ex 14.3, Extreme Values and Saddle Point, Derivative Tests for Local Extreme Values.	Quiz # 1
Week 03	Absolute Maxima and Minima on Closed Bounded Region, Ex 14.7, Constrained Maxima and Minima, Method of Lagrange Multipliers, Ex 14.8, Chain Rule.	Assignment # 1 Quiz # 2
Week 04	Ex 14.4, Directional Derivatives and Gradient Vector, Applications of Gradient, Ex 14.5.	Quiz # 3
Week 05	Tangent Planes and Normal Lines, Linearization, Ex 14.6, Automatic Differentiation.	Assignment # 2 Quiz # 4
Week 06	Computational Graphs, 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	Line Integrals, Ex 16.1.	Assignment # 5 **Sessional II**
Week 12	Vector Fields, Gradient Fields, Line Integrals of Vector Fields, Ex 16.2, Path Independence, Conservative Fields, Line Integral in Conservative Fields.	
Week 13	Potential Functions, Ex 16.3, Divergence, 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	The Curl Vector Field, Divergence in Three Dimensions, Divergence Theorem, Ex 16.8. Revision.	