Lahore University of Management Sciences

MATH 309 –Introduction to Analysis II

Fall 2023-2024

Instructor	Shaheen Nazir
Room No.	9-153A
Office Hours	TBA
Email	shaheen.nazir@lums.edu.pk
Telephone	8250
Secretary/TA	Shazia Zafar & Noreen Sohail/
TA Office Hours	
Course URL (if any)	LMS website

Course Teaching Methodology

- **Teaching Methodology:** Lectures will be delivered on time scheduled by the Ro.
- **Lecture Details:** Lecture notes and recorded zoom lectures will be uploaded on LMS.

Course Basics

Credit Hours	3			
Lecture(s)	Nbr of Lec(s) Per Week	2	Duration	75 min
Recitation/Lab (per week)	Nbr of Lec(s) Per Week		Duration	
Tutorial (per week)	Nbr of Lec(s) Per Week	1	Duration	50 min
Meeting Times		TBA	Location	TBA

Course Distribution

Core	For Math Major
Elective	
Open for Student Category	All students
Close for Student Category	None

COURSE PREREQUISITE(S)

Math 205 (Introduction to Analysis-I)

COURSE DESCRIPTION

Introduction to Analysis II is the sequel to Introduction to Analysis I, and together these two courses constitute the foundations of real analysis in mathematics. This course is designed to prepare students for future advanced analysis and functional analysis courses. It lays the foundation for several other areas, such as complex analysis, topology, dynamical systems, quantum mechanics, and mathematical statistics. The rigorous treatment of the subject in terms of theory and examples gives students the flavor of mathematical reasoning and intuition for other advanced topics in mathematics. Differentiability and Riemann integrals are introduced and their properties are studied in details. Topics covered are open, closed, and compact sets of real numbers. Sequences and series of functions, point wise and uniform convergence. Power series and Taylor series. Metric spaces: basic notions generalized from the setting of the real numbers.

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COURSE GOAL

In this course, we will

- construct the Riemann Integral and state its properties
- state the Fundamental Theorem of Calculus and use it in proofs
- define pointwise and uniform convergence of series of functions
- use the Weierstrass M-Test to check for uniform convergence of series
- construct Taylor Series and state Taylor's Theorem;
- identify necessary and sufficient conditions for term-by-term differentiation of power series
- learn improper integrals
- differentiate Riemann and Lebesgue Integrable functions
- define metric space; open, closed sets
- learn complete and compact spaces

Learning Outcomes

At the end of the course, students will:

- present an overview of the basic properties of metric spaces;
- construct rigorous mathematical proofs of basic results in integration;
- appreciate how abstract ideas and rigorous methods in mathematical analysis can be applied to important practical problems,
- recognize the power of abstraction and generalization, and apply logical reasoning to investigate mathematical work with independent judgment,
- apply rigorous deductive reasoning in conjunction with quantative methods to analyze and solve problems related to math profession

Grading Breakup and Policy (tentative)

Assignment(s): 15%
Due dates: 20th Sept for A1, 4th Oct for A2, 18th Oct for A3, 8th Nov for A4, 22nd Nov for A5

Quiz(s): 20%
27th Sep for Q1, 11th Oct for Q2, 15th Nov for Q3, 29th Nov for Q4

Project: 10% (dates for presentations will be announced later)
Every student will be assigned a topic/Theorem. **Your task** is to **write a short note** and a **presentation** on your assigned topic. The write-up should contain your original explanation with elaborated examples. Topics will be announced later.

Midterm Examination: 20% (25th Oct class time)

Final Examination (Written and Oral): 35 % (TBA)

Dates for graded components:
The date for assignments, quizzes and exams will be strictly adhered to and late submissions will not be entertained, unless faced with some unforeseen circumstances.

If you have accessibility issues or any other emergency, please email me regarding graded instruments ASAP.

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Examination Detail	
Midterm Exam	Yes/No: Yes Date:
Final Exam	Yes/No: Yes Exam Specifications: **Comprehensive** Date: TBA

Academic Honesty

The principles of truth and honesty are recognized as fundamental to a community of teachers and students. This means that all academic work will be done by the student to whom it is assigned without unauthorized aid of any kind. Plagiarism, cheating and other forms of academic dishonesty are prohibited. Any instances of academic dishonesty in this course (intentional or unintentional) will be dealt with swiftly and severely. Potential penalties include receiving a failing grade on the assignment in question or in the course overall. For further information, students should make themselves familiar with the relevant section of the LUMS student handbook.

Harassment Policy

SSE, LUMS and particularly this class, is a harassment free zone. There is absolutely zero tolerance for any behavior that is intended, or has the expected result of making anyone uncomfortable and negatively impacts the class environment, or any individual's ability to work to the best of their potential.

In case a differently-abled student requires accommodations for fully participating in the course, students are advised to contact the instructor so that they can be facilitated accordingly.

If you think that you may be a victim of harassment or if you have observed any harassment occurring in the purview of this class, please reach out and speak to me. If you are a victim, I strongly encourage you to reach out to the Office of Accessibility and Inclusion at oai@lums.edu.pk or the sexual harassment inquiry committee at harassment@lums.edu.pk for any queries, clarifications, or advice. You may choose to file an informal or a formal complaint to put an end of offending behavior. You can find more details regarding the LUMS sexual harassment policy here.

To file a complaint, please write to harassment@lums.edu.pk**.**

SSE Council on Equity and Belonging

In addition to LUMS resources, SSE's Council on Belonging and Equity is committed to devising ways to provide a safe, inclusive and respectful learning environment for students, faculty and staff. To seek counsel related to any issues, please feel free to approach either a member of the council or email at cbe.sse@lums.edu.pk

Mental Health Support at LUMS

For matters relating to counselling, kindly email student.counselling@lums.edu.pk, or visit https://osa.lums.edu.pk/content/student-counselling-office for more information.

You are welcome to write to me or speak to me if you find that your mental health is impacting your ability to participate in the course. However, should you choose not to do so, please contact the Counselling Unit and speak to a counsellor or speak to the OSA team and ask them to write to me so that any necessary accommodations can be made.

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COURSE OVERVIEW			
Week/ Lecture/ Module	**Topics**	**Recommended Readings**	**Objectives/ Application**
1-4	**Review** Real numbers, sequences and series of real numbers, Limits, Continuity, Uniform Continuity and differentiability	Lecture Notes	Recall and review the contents learnt in Math 205
5-9	**The Riemann Integral** The Riemann sum, Darboux integration, Riemann Integrable Functions, The Fundamental Theorems	Chapter 7[BS] Chapter 11[T1]	Rigorous definition of integration and its properties; Formal proofs of all forms of Fundamental theorem of Calculus
10-16	**Metric Spaces** Examples of Metric Spaces, Open Sets, Closed Sets, Convergent Sequences, Continuous Mappings Between Metric Spaces, Complete Metric Spaces, Compact Metric Spaces	Lecture notes & [Ru] Chapter 1&2[T2]	Basic definition, properties of metric spaces are given. It generalize the idea of real line with distance function to an abstract space with some metric/distance function
17-21	**Sequences and Series of Functions** Pointwise and Uniform Convergence, Continuity and Uniform Convergence, Integration and Uniform Convergence, Uniform Convergence and Differentiation, Series of Functions, Power Series	Chapter 8 & 9(Section 9.4) [BS] Chapter 4&4[T2]	In Math 205, sequences and series of real numbers are studied. In this part, we describe these notions for functions; also describe some important functions as power series
22-28	**Improper and Lebesgue Integrals** Improper Integrals, Infinite Intervals, step functions on intervals, Lebesgue Integrable functions on intervals, Relation with Riemann integrals	Lecture notes & [Tr]	Convergence or divergence of improper integrals will be discussed. Also, we will introduce and learn the Lebesgue integrals.

Textbook(s)/Supplementary Readings

[BS] R. G. Bartle, D. R. Sherbert, Introduction to Real Analysis, 3rd edition, John Wiley & Sons, Inc 2000

[T1] Terence Tao, Analysis I, Third Edition, Springer, 2016

[T2] Terence Tao, Analysis II, Third Edition, Springer, 2016

[Tr] W. Trench, Introduction to Real Analysis

[TB2] B S. Thomson B. Bruckner, A M. Bruckner, Elementary Real Analysis Prentice Hall (Pearson) 2001

[L] Notes on Real Analysis by Lee Larson. Available at http://www.math.louisville.edu/~lee/ira/IntroRealAnal.pdf

[Ru] W. Rudin,, Principles of Mathematical Analysis, 3rd edition

Course material and any info about the course will be uploaded on LMS. It is your responsibility to visit LMS regularly.