SEMESTER LEARNING PLAN

INTRODUCTION TO REAL ANALYSIS COURSES
(23H01120703)

TEACHING TEAM

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STUDI PROGRAM OF MATHEMATICS - S1
FACULTY OF MATHEMATICS AND NATURAL SCIENCES
HASANUDDIN UNIVERSITY
MAKASSAR
2025

STUDY PROGRAM OF MATEMATIKA - S1
FACULTY OF MATHEMATICS AND NATURAL SCIENCES
HASANUDDIN UNIVERSITY

Vision

The scientific vision is to become a study program with an international reputation in the development of mathematics based on the Indonesian maritime continent by 2030

Vision Strategy

Misson

To fulfill the above vision, the Undergraduate Mathematics Study Program has four missions, namely:

- Organizing innovative and effective mathematics learning to improve the quality and creativity of students in order to compete nationally and internationally.
- Improving a research culture that produces internationally reputable publications.
- Playing an active role in community service activities and collaborating with other academic institutions, government, business, media and society.
- Carry out governance in the Mathematics Study Program that is effective, efficient and transparent based on IT and ISO 9001:2015 standards to achieve the tridharma goals.

Graduate Profiles

Gagal diterjemahkan

PLO charged to courses

CPL-1 (ILO 1) - Students are able to demonstrate an advanced understanding of basic pure and simple applied mathematics.

CPL-2 (P2) - The students are able to identify objects, techniques, and theorems in fundamental mathematics, and making a connection for solving problems

CPL-3 (KU1) - The students are able to analyse a mathematical problem with logic, analytic, and systematic structure

Course Learning Outcomes (CLO)

CPMK-1: Students are able to describe the structure of real numbers through studying algebraic properties, sequence properties, completeness properties and Archimedes properties in a logical and structured manner to support understanding of basic concepts. (CPL1)

CPMK-2: Students are able to apply the concept of real numbers, the concept of supremum/infimum, the concept of topology to analyze the behavior of sequences of real numbers. (CPL2)

CPMK-3: Students are able to integrate the concepts of real number sequences, limits and continuity of real functions in an analytical framework to solve proof of concept/property problems. (CPL3)

Sub-CLO

Sub CPMK-1: Students are able to explain the relationship between algebraic properties, sequence properties, and completeness properties in consistently forming a real number system. (CPMK-1)

Sub CPMK-2: Students are able to use Archimedes' properties in proving the existence of the supremum/infimum of finite sets as well as the relationship between rational and irrational numbers in the real number system. (CPMK-1)

Sub CPMK-3: Students are able to apply the properties of completeness, interior points and cluster points to interval characterization analysis in the context of open set and closed set topology. (CPMK-2)

Sub CPMK-4: Students are able to analyze the properties of convergence, divergence and monotonicity of real number sequences through the definition of sequence limits and relate them to the concepts of cluster points and finite sets. (CPMK-2)

Sub CPMK-5: Students are able to integrate the concepts of sequence limits and function limits to analyze their relationship in forming the concept of continuity of real functions. (CPMK-3)

Sub CPMK-6: Students are able to prepare systematic and structured analytical proofs regarding continuity and limits of real functions based on the epsilon-delta definition and basic theorems of real analysis. (CPMK-3)

Learning Analytics

Introduction to Real Analysis

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Students are able to prepare systematic and structured analytical proofs regarding continuity and limits of real functions based on the epsilon-delta definition and basic theorems of real analysis. (CPMK-3)

↑

Students are able to integrate the concepts of sequence limits and function limits to analyze their relationship in forming the concept of continuity of real functions. (CPMK-3)

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Students are able to analyze the properties of convergence, divergence and monotonicity of real number sequences through the definition of sequence limits and relate them to the concepts of cluster points and finite sets. (CPMK-2)

↑

Students are able to apply the properties of completeness, interior points and cluster points to interval characterization analysis in the context of open set and closed set topology. (CPMK-2)

↑

Students are able to use Archimedes' properties in proving the existence of the supremum/infimum of finite sets as well as the relationship between rational and irrational numbers in the real number system. (CPMK-1)

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Students are able to explain the relationship between algebraic properties, sequence properties, and completeness properties in consistently forming a real number system. (CPMK-1)

Have passed the course Basic Mathematics I, Mathematical Logic and Sets and Basic Mathematics II

HASANUDDIN UNIVERSITY
FAKULTY OF MATHEMATICS AND NATURAL SCIENCES
STUDY PROGRAM OF MATHEMATICS - S1
SEMESTER LEARNING PLAN

Course	Code	Cource Group	Credits	SEMESTER	Compilation Date
Introduction to Real Analysis	23H01120703	Analysis	3	3	10 Agustus 2024

AUTHORITY	SLP Developer Lecturer	Coordinator	Head of Study Program
	Jusmawati Massalesse, S.Si.,M.Si., Naimah Aris, S.Si.,M.Math.	Naimah Aris, S.Si.,M.Math.	Prof. Dr. Nurdin, S.Si., M.Si.

Learning Outcomes Course		
	SLOs that are imposed on the course	
	SLO-1:	Mahasiswa memiliki pemahaman yang relatif mendalam dalam matematika murni dan matematika terapan sederhana.
	SLO-2:	Mahasiswa mampu mengidentifikasi objek, teknik, dan sifat dalam matematika dasar, dan membuat koneksi untuk menyelesaikan masalah
	SLO-3:	Mahasiswa mampu menganalisis suatu masalah matematika dengan logika, analitik, dan struktur sistematis
	SLO ⇒ Course Learning Outcomes	
	After completing this course, it is expected:	
	SLO-1	**CLO-1:** Students are able to describe the structure of real numbers through studying algebraic properties, sequence properties, completeness properties and Archimedes properties in a logical and structured manner to support understanding of basic concepts.
	SLO-2	**CLO-2:** Students are able to apply the concept of real numbers, the concept of supremum/infimum, the concept of topology to analyze the behavior of sequences of real numbers.
	SLO-3	**CLO-3:** Students are able to integrate the concepts of real number sequences, limits and continuity of real functions in an analytical framework to solve proof of concept/property problems.
	CLO ⇒ Sub-CLO	
	CLO-1	**Sub-CLO-1:**Students are able to explain the relationship between algebraic properties, sequence properties, and completeness properties in consistently forming a real number system.
		Sub-CLO-2: Students are able to use Archimedes' properties in proving the existence of the supremum/infimum of finite sets as well as the relationship between rational and irrational numbers in the real number system.
	CLO-2	**Sub-CLO-3:**Students are able to apply the properties of completeness, interior points and cluster points to interval characterization analysis in the context of open set and closed set topology.
		Sub-CLO-4: Students are able to analyze the properties of convergence, divergence and monotonicity of real number sequences through the definition of sequence limits and relate them to the concepts of cluster points and finite sets.

	CLO-3	**Sub-CLO-5:**Students are able to integrate the concepts of sequence limits and function limits to analyze their relationship in forming the concept of continuity of real functions.
		Sub-CLO-6: Students are able to prepare systematic and structured analytical proofs regarding continuity and limits of real functions based on the epsilon-delta definition and basic theorems of real analysis.

Correlation between SLOs/CLOs to Sub-CLOs

SLOs that are charged on the Course	CPMK	SUB CPMK	Form of Assessment*					Weight	Value	Student Score
			Formative	Sumative						
				Case Studies	Quiz	Written Exam	Written Exam			
SLO-1	CLO-1	SUB-CLO-1	Discipline, perseverance, activeness, and short questions and answers.	10	0	6.67	0	16.67		
SLO-1	CLO-1	SUB-CLO-2		10	0	6.67	0	16.67		
SLO-2	CLO-2	SUB-CLO-3		10	0	6.67	0	16.67		
SLO-2	CLO-2	SUB-CLO-4		0	10	0	6.67	16.67		
SLO-3	CLO-3	SUB-CLO-5		10	0	0	6.67	16.67		
SLO-3	CLO-3	SUB-CLO-6		10	0	0	6.67	16.67		
				50	10	20	20	100		

Course Description	In general, this course discusses completely ordered fields, topology, sequences of real numbers, limits and continuity of real functions. The complete ordered field discusses the algebraic properties of real numbers, the properties of sequences derived from the properties of sets of positive numbers, finite sets, supprimum-infimum and their applications. On the subject of topology, the discussion focuses on the meaning of open sets and closed sets, as well as their relation to interior points and limit points. Next, the topic of real number sequences discusses the convergence of sequences, convergence and divergence criteria, the monotone convergence theorem, the Bolzano Weierstrass Theorem and Cauchy sequences are topics discussed in real number sequences. The final material, namely about limits and continuity of real functions, discusses the meaning of limits and continuity with an emphasis on the meaning of epsilon-delta, Bolzano's middle value theorem, maximum-minimum theorem, and uniform continuity, and the difference between ordinary continuity and uniform continuity.

Learning Materials/Subjects	1. Real Number System: Algebraic Properties, Sequence Properties and Completeness Properties of Numbers Real, Archimedes Properties and their applications. 2. Topology: Open Sets, Closed Sets and Their Characteristics 3. Real Number Sequences 4. Function Limits 5. Continuity
Reference	**Main References**
	1. Bartle, Robert. G and Sherbert, Donald R., 2000, Introduction to Real Analysis, John Wiley and Sons. 3rd ed. 2. Trench, William F.,2003 , Intoduction to Real Analysis, Pearson Education. 3. Stoll, Manfred, 2021, ,"An Introduction to Real Analysis", Addison-Wesley Educattional Publishers Inc., 3rd ed.
	Additional References
	Introductory Analysis Teaching Materials Real
Teaching Team	Prof. Dr. Budi Nurwahyu, MS., Jusmawati Massalesse, S.Si.,M.Si., Naimah Aris, S.Si.,M.Math., Dr. Muh. Nur, S.Si., M.Si.
Course requirement	Basic Mathematics I, Mathematical Logic and Sets, Basic Mathematics II

Week	**Sub CPMK (End-of-stage learning ability)**	**Penilaian (*Assesment*)**		**Learning Forms and Methods [time estimate]**		**Content**	**Weight of Assessment (%)**
		Indicator	**Techniques & Criteria**	**Offline**	**Online**		
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**

1-2	Students are able to explain the relationship between algebraic properties, sequence properties, and completeness properties in consistently forming a real number system. (CPMK-1)	**Formative:** Discipline, Activeness, Short Questions and Answers. **Sumative:** • Ability to explain the relationship between algebraic properties and sequence properties in the real number system. • Ability to identify the role of completeness properties in the formation of real numbers from rational numbers. • Ability to provide examples of applying the property of completeness to prove the existence of a simple limit or supremum.	**Formative Criteria:** Discipline, perseverance, activeness, and short questions and answers. **Sumative Criteria:** Case Studies (10) dinilai dengan rubrik 01 **Assessment Technique:** Non Test	**Studying:** Cooperative learning (Cooperative learning) Learning activities: lectures, taking quizzes and assignments (conceptual-based Case Study) TM:2x3x50; PT:2x3x60; BM:2x3x60		Real Number System: Properties Algebra, Properties Sequence, Characteristics Completeness	10

3-4	Students are able to use Archimedes' properties in proving the existence of the supremum/infimum of finite sets as well as the relationship between rational and irrational numbers in the real number system. (CPMK-1)	**Formative:** Discipline, Activeness, Short Questions and Answers. **Sumative:** - Ability to prove Archimedes' deep nature real number context. - The ability to determine the supremum or infimum of finite sets using Archimedes' property. - Capabilities indicates that the number rationals are dense in real numbers, but not complete	**Formative Criteria:** **Sumative Criteria:** Case Studies (10) dinilai dengan rubrik 01 **Assessment Technique:** Non Test	**Studying:** Collaborative learning (Collaborative Learning) Learning activities: lectures, taking quizzes and assignments (conceptual-based Case Study) TM: 2x3x50; PT: 2x3x60; BM: 2x3x60		Value absolutes and number lines, completeness R, properties supprimum and infimum, Archimedes' property, and Intervals.	10
5-7	Students are able to apply the properties of completeness, interior points and cluster points to interval characterization analysis in the context of open set and closed set topology. (CPMK-2)	**Formative:** Gagal diterjemahkan **Sumative:** - Define interior points, boundary points, and limit points of a set of real numbers. - Identifies open sets and sets close based on the topology definition. - Apply the concept of cluster points in the proof characterization of closed and open intervals.	**Formative Criteria:** **Sumative Criteria:** Case Studies (10) dinilai dengan rubrik 01 **Assessment Technique:** Test and Non-Test	**Studying:** Cooperative learning (Cooperative learning) Learning activities: lectures, taking quizzes and assignments (conceptual-based Case Study) TM: 3x3x50; PT: 3x3x60; BM: 3x3x60		Topology: cluster points and interior points, open sets and closed sets, characteristics of open sets and closed sets.	10
8	Written Exam						20

9-11	Students are able to analyze the properties of convergence, divergence and monotonicity of real number sequences through the definition of sequence limits and relate them to the concepts of cluster points and finite sets. (CPMK-2)	**Formative:** Discipline, Activeness, Short Questions and Answers. **Sumative:** - Ability connecting Convergence Theorem Monotony with convergence of the sequence - Capabilities using the Bolzano-Weierstrass Theorem and the Divergence Criterion in the determination convergence of the sequence - Ability to identify what a sequence of numbers is real is the Cauchy sequence	**Formative Criteria:** **Sumative Criteria:** Quiz (10) dinilai dengan rubrik 01 **Assessment Technique:** Test and Non-Test	**Studying:** Collaborative learning (Collaborative Learning) Learning activities: lectures, taking quizzes and assignments (conceptual-based Case Study) TM: 3x3x50; PT: 3x3x60; BM: 3x3x50.		Real Number Sequence: - Theorem Limit - Line Monotonous - Sub sequences and the Bolzano-Weierstrass Theorem - Criteria Cauchy	10
12-13	Students are able to integrate the concepts of sequence limits and function limits to analyze their relationship in forming the concept of continuity of real functions. (CPMK-3)	**Formative:** Discipline, Activeness, Short Questions and Answers. **Sumative:** · Ability to integrate the concepts of sequence limits and limits function. · Ability to analyze the relationship between the two in forming concepts real function continuity.	**Formative Criteria:** **Sumative Criteria:** Case Studies (10) dinilai dengan rubrik 01 **Assessment Technique:** Test and Non-Test	**Studying:** Collaborative learning (Collaborative Learning) Learning activities: lectures, taking quizzes and assignments (conceptual-based Case Study) TM: 2x3x50; PT: 2x3x60; BM: 2x3x50.		Limit Function - Convergence Criteria and Convergence Criteria limit - Limit Theorem - Expansion of the concept of limits	10

14-15	Students are able to prepare systematic and structured analytical proofs regarding continuity and limits of real functions based on the epsilon-delta definition and basic theorems of real analysis. (CPMK-3)	**Formative:** Discipline, Activeness, Short Questions and Answers. **Sumative:** · Capabilities explain limits and continuity at a point using notation epsilon-delta. · Ability to prove uniform continuity using Lipschitz conditions · Ability to compile proofs of continuity and discontinuity of function with a clear, systematic and logical structure consistent.	**Formative Criteria:** **Sumative Criteria:** Case Studies (10) dinilai dengan rubrik 01 **Assessment Technique:** Test and Non-Test	**Studying:** Case Study (Case Study) Learning activities: lectures, taking quizzes and assignments (conceptual-based Case Study) TM: 2x3x50; PT: 2x3x60; BM: 2x3x50.		Continuity over Intervals Theorem Maximum-Minimum Continuity Uniform	10
16	Written Exam						20
							100

Matrix of SLO, CLO, and Assessment Method

SLO / CLO	CLO-1	CLO-2	CLO-3
CPL-1 (ILO 1)	Case Studies (Weight 10%) Case Studies (Weight 10%)		
CPL-2 (P2)		Case Studies (Weight 10%) Quiz (Weight 10%)	
CPL-3 (KU1)			Case Studies (Weight 10%) Case Studies (Weight 10%)

Evaluation Type and Assessment Weight

Type	Assessment Weight
Case Studies	50
Quiz	10
Written Exam	20
Written Exam	20
Total	100

Assessment and Evaluation of Student Achievement of CLOs

SLOs that are charged on the Course	CLO	SUB CLO	Form of Assessment*					Weight	Value	Student Score
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SLO-2	CLO-2	SUB-CLO-4		0	10	0	6.67	16.67		
SLO-3	CLO-3	SUB-CLO-5		10	0	0	6.67	16.67		
SLO-3	CLO-3	SUB-CLO-6		10	0	0	6.67	16.67		
				50	10	20	20	100		

Lampiran Rubrik 01 | ASSESMENT TERTULIS

Kriteria Penilaian	Bobot/Skor Penilaian				
	5	4	3	2	1/0
Konsep/ metode yang digunakan	Penjelasan konsep /metode (*) sangat lengkap dan akurat	Penjelasan konsep/metode (*) cukup jelas tetapi beberapa informasi tidak dituliskan secara lengkap.	Penjelasan konsep/metode (*) kurang jelas dan banyak informasi yang tidak dituliskan	Penjelasan yang dituliskan hampir tidak berkaitan dengan konsep/ metode (*)	Tidak memberikan konsep yang dibutuhkan
Sistematika penulisan/ pembuktian	Sistematika penulisan/ pembuktian sangat jelas dan terstruktur	Sistematika penulisan/ pembuktian cukup jelas namun ada langkah yang hilang	Sistematika penulisan/ pembuktian kurang jelas	Sistematika penulisan/ pembuktian tidak jelas	Jawaban tidak benar/ tidak ada
Interpretasi geometri/ kualitatif/ kuantitatif.	Interpretasi geometri/ kualitatif/ kuantitaBtif (*) tepat dan lengkap	Interpretasi geometri/ kualitatif/ kuantitatif (*) cukup lengkap/ tepat	Interpretasi geometri/ kualitatif/ kuantitatif (*) kurang lengkap/ tepat	Interpretasi geometri/ kualitatif/ kuantitatif(*) tidak lengkap/ tepat	Interpretasi geometri/ kualitatif/kuantitatif(*) tidak benar
Perhitungan/kesimpulan	Perhitungan/ kesimpulan sangat akurat/tepat dan disertai alasan yang mendasarinya	Perhitungan/ kesimpulan cukup akurat/tepat dan disertai alasan yang mendasarinya	Kesimpulan cukup tepat, namun tidak disertai alasan yang jelas	Perhitungan/ kesimpulan kurang akurat/tepat dan tidak disertai alasan yang mendasarinya	Perhitungan/kesimpulan salah