SEMESTER LEARNING PLAN

INTRODUCTION TO FUNCTIONAL ANALYSIS COURSES
(23H01131203)

TEACHING TEAM

Naimah Aris, S.Si.,M.Math.
197110031997022001

Dr. Muh. Nur, S.Si., M.Si.
198505292008121002

Dr. Muhammad Zakir, M.Si.
196402071991031013

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

CPL-4 (KU2) - The students are able to use their sufficiently mathematical critical thinking for abstraction and generalization of a mathematical problem

CPL-7 (KK3) - The students are able to demonstrate mathematical skills which include interpretation, connecting problems, solving problems, and communicating individually or teamwork

Course Learning Outcomes (CLO)

CPMK-1: Students are able to understand the definition of metric space and determine its completeness. (CPL2)

CPMK-2: Demonstrate the properties of linear normed spaces and Banach spaces (CPL2)

CPMK-3: Able to prove basic theorems for normed spaces and Banach spaces as well as transformations between the two (CPL4)

CPMK-4: Developing students' ability to find information through the world wide web, and present concepts in written and oral skills both independently and in groups. (CPL7)

Sub-CLO

Sub CPMK-1: Be able to explain the meaning of metric space, prove several examples of what is a metric space and what is not a metric space (CPMK-1)

Sub CPMK-2: Students understand and are able to explain the definition of open, closed and surrounding sets in metric space, and are able to prove that metric space is a topological space. (CPMK-1 dan CPMK-4)

Sub CPMK-3: Students are able to prove Cauchy Schwarz inequality, Holder inequality, and Minskowski inequality (CPMK-1 dan CPMK-2)

Sub CPMK-4: Students are able to prove the completeness of R^n, C^n, l^p, and L^p in metric spaces, as well as prove theorems related to the completeness of metric spaces. (CPMK-1 dan CPMK-4)

Sub CPMK-5: Students are able to provide examples of incomplete spaces in metric space. (CPMK-1 dan CPMK-4)

Sub CPMK-6: Able to explain that space R^n, C^n, l^p, L^p is a vector space, able to explain the meaning of norm space, prove that norm space is a metric space, and able to explain that space R^n, C^n, l^p, L^p is a norm space (CPMK-2)

Sub CPMK-7: Able to explain the concept of convergent sequences and Cauchy sequences in normed spaces and be able to prove that R^n, C^n, l^p, L^p and the continuous space C[a,b] are Banach spaces. (CPMK-2 dan CPMK-4)

Sub CPMK-8: Be able to explain the meaning of norm equivalence, and be able to prove that every norm in finite dimensional space is equivalent (CPMK-3)

Sub CPMK-9: Able to explain the meaning of Compact Sets, able to prove Riesz's Lema (CPMK-3)

Sub CPMK-10: Able to explain the meaning of linear operators, limited linear operators, in general, kernel and range as well as finding the kernel and range of a linear operator.Be able to explain the meaning of linear functional, limited linear functional, prove that the set of limited linear operators is a Banach space (CPMK-3)

Learning Analytics

Introduction to Functional Analysis

↑

Able to explain the meaning of linear operators, limited linear operators, in general, kernel and range as well as finding the kernel and range of a linear operator.Be able to explain the meaning of linear functional, limited linear functional, prove that the set of limited linear operators is a Banach space (CPMK-3)

↑

Able to explain the meaning of Compact Sets, able to prove Riesz's Lema (CPMK-3)

↑

Be able to explain the meaning of norm equivalence, and be able to prove that every norm in finite dimensional space is equivalent (CPMK-3)

↑

Able to explain the concept of convergent sequences and Cauchy sequences in normed spaces and be able to prove that R^n, C^n, l^p, L^p and the continuous space C[a,b] are Banach spaces. (CPMK-4 dan CPMK-2)

↑

Able to explain that space R^n, C^n, l^p, L^p is a vector space, able to explain the meaning of norm space, prove that norm space is a metric space, and able to explain that space R^n, C^n, l^p, L^p is a norm space (CPMK-2)

↑

Students are able to provide examples of incomplete spaces in metric space. (CPMK-1 dan CPMK-4)

↑

Students are able to prove the completeness of R^n, C^n, l^p, and L^p in metric spaces, as well as prove theorems related to the completeness of metric spaces. (CPMK-1 dan CPMK-4)

↑

Students are able to prove Cauchy Schwarz inequality, Holder inequality, and Minskowski inequality (CPMK-1 dan CPMK-2)

↑

Students understand and are able to explain the definition of open, closed and surrounding sets in metric space, and are able to prove that metric space is a topological space. (CPMK-1 dan CPMK-4)

↑

Be able to explain the meaning of metric space, prove several examples of what is a metric space and what is not a metric space (CPMK-1)

Have passed the course Linear Algebra I, Introduction to Real Analysis and Real Analysis

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 Functional Analysis	23H01131203		3	5	10 Agustus 2025

AUTHORITY	SLP Developer Lecturer	Coordinator	Head of Study Program
	Naimah Aris, S.Si.,M.Math., Dr. Muhammad Zakir, M.Si.	Dr. Muhammad Zakir, M.Si.	Dr. Firman, S.Si.,M.Si.

Learning Outcomes	**SLOs that are imposed on the course**	
	SLO-2:	Mahasiswa mampu mengidentifikasi objek, teknik, dan sifat dalam matematika dasar, dan membuat koneksi untuk menyelesaikan masalah
	SLO-4:	Mahasiswa dapat menggunakan pemikiran kritis matematis mereka yang cukup untuk abstraksi dan generalisasi masalah matematika berdasarkan hasil analisis informasi dan data
	SLO-7:	Mahasiswa dapat menunjukkan keterampilan matematika termasuk menghubungkan masalah, menyelesaikan masalah, interpretasi, dan berkomunikasi secara individu atau dengan kerja tim
	SLO ⇒ Course Learning Outcomes	
	After completing this course, it is expected:	
	SLO-2	**CLO-1:** Students are able to understand the definition of metric space and determine its completeness.
		CLO-2: Demonstrate the properties of linear normed spaces and Banach spaces
	SLO-4	**CLO-3:** Able to prove basic theorems for normed spaces and Banach spaces as well as transformations between the two
	SLO-7	**CLO-4:** Developing students' ability to find information through the world wide web, and present concepts in written and oral skills both independently and in groups.
	CLO ⇒ Sub-CLO	
	CLO-1	**Sub-CLO-1:**Be able to explain the meaning of metric space, prove several examples of what is a metric space and what is not a metric space
		Sub-CLO-2: Students understand and are able to explain the definition of open, closed and surrounding sets in metric space, and are able to prove that metric space is a topological space.
		Sub-CLO-3: Students are able to prove Cauchy Schwarz inequality, Holder inequality, and Minskowski inequality
		Sub-CLO-4: Students are able to prove the completeness of R^n, C^n, l^p, and L^p in metric spaces, as well as prove theorems related to the completeness of metric spaces.

Course		
		Sub-CLO-5: Students are able to provide examples of incomplete spaces in metric space.
	CLO-2	**Sub-CLO-3:**Students are able to prove Cauchy Schwarz inequality, Holder inequality, and Minskowski inequality
		Sub-CLO-6: Able to explain that space R^n, C^n, l^p, L^p is a vector space, able to explain the meaning of norm space, prove that norm space is a metric space, and able to explain that space R^n, C^n, l^p, L^p is a norm space
		Sub-CLO-7: Able to explain the concept of convergent sequences and Cauchy sequences in normed spaces and be able to prove that R^n, C^n, l^p, L^p and the continuous space C[a,b] are Banach spaces.
	CLO-3	**Sub-CLO-8:**Be able to explain the meaning of norm equivalence, and be able to prove that every norm in finite dimensional space is equivalent
		Sub-CLO-9: Able to explain the meaning of Compact Sets, able to prove Riesz's Lema
		Sub-CLO-10: Able to explain the meaning of linear operators, limited linear operators, in general, kernel and range as well as finding the kernel and range of a linear operator.Be able to explain the meaning of linear functional, limited linear functional, prove that the set of limited linear operators is a Banach space
	CLO-4	**Sub-CLO-2:**Students understand and are able to explain the definition of open, closed and surrounding sets in metric space, and are able to prove that metric space is a topological space.
		Sub-CLO-4: Students are able to prove the completeness of R^n, C^n, l^p, and L^p in metric spaces, as well as prove theorems related to the completeness of metric spaces.
		Sub-CLO-5: Students are able to provide examples of incomplete spaces in metric space.
		Sub-CLO-7: Able to explain the concept of convergent sequences and Cauchy sequences in normed spaces and be able to prove that R^n, C^n, l^p, L^p and the continuous space C[a,b] are Banach spaces.
	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	Independent Assignment	Written Exam	Written Exam			
SLO-2	CLO-1	SUB-CLO-1	Discipline, perseverance and activeness	10	0	0	0	10		
SLO-7	CLO-4	SUB-CLO-2	Discipline, perseverance and activeness	10	0	0	0	10		
SLO-2	CLO-2	SUB-CLO-3	Discipline, perseverance and activeness	10	0	0	0	10		
SLO-7	CLO-4	SUB-CLO-4	Discipline, perseverance and activeness	10	0	0	0	10		
SLO-7	CLO-4	SUB-CLO-5	Discipline, perseverance and activeness	10	0	0	0	10		
SLO-2	CLO-2	SUB-CLO-7	Discipline, perseverance and activeness	0	25	0	0	25		
SLO-4	CLO-3	SUB-CLO-8	Discipline, perseverance and activeness	0	0	10	0	10		

SLOs that are charged on the Course	CPMK	SUB CPMK	Form of Assessment*					Weight	Value	Student Score
			Formative	Sumative						
				Case Studies	Independent Assignment	Written Exam	Written Exam			
SLO-4	CLO-3	SUB-CLO-9	Discipline, perseverance and activeness	0	0	0	15	15		
				50	25	10	15	100		

Course Description	This course introduces metric spaces, open, closed sets, environments, topological spaces in metric spaces, apart from that this course discusses norm spaces and convergent sequences, Cauchy and completeness in metric spaces and norm spaces, also discusses norm equivalence as well as linear operators and linear functionals, as well as limited linear and limited linear functionals. By presenting the material in this course, it is hoped that you will be able to master the basic techniques of functional analysis and apply functional analysis in solving scientific problems, especially in the field of mathematics, whether pure or applied.
Learning Materials/Subjects	Metric Spaces, Neighborhoods, Open Sets, Closed Sets, Completeness of Metric Spaces, Vector Spaces, Norm Spaces, Banach Spaces, Finite Dimensional Norm Spaces, Operators and Linear Functionals.
Reference	**Main References** 1. Introductory Functional Analysis With Applications, Kreyszig. E, John Wiley & Sons. Inc. New York 1978. 2. Principles of Functional Analysis second edition, Martin Schechter.American Mathematical Society, 2002 **Additional References** 1. Sumanang. M, Introduction to Functional Analysis, UPI, Bandung 2010. 2. Principles of Functional Analysis second edition, Martin Schechter.American Mathematical Society, 2002 3. Nur, M., Bahri, M., & Islamiyati, A. (2024). A new 2-norm in normed spaces. In AIP Conference Proceedings (Vol. 3161, p. 060006). PROCEEDINGS OF 5TH INTERNATIONAL CONFERENCE ON SUSTAINABLE INNOVATION IN ENGINEERING AND TECHNOLOGY 2023. AIP Publishing. https://doi.org/10.1063/5.0164441 4.Other learning resources
Teaching Team	Naimah Aris, S.Si.,M.Math., Dr. Muh. Nur, S.Si., M.Si., Dr. Muhammad Zakir, M.Si.
Course requirement	Linear Algebra I, Introduction to Real Analysis, Real Analysis

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	Be able to explain the meaning of metric space, prove several examples of what is a metric space and what is not a metric space (CPMK-1)	**Formative:** Discipline, Liveliness, Tanya short answer. **Sumative:** Precision and clarity in using the definition of metric space, Accuracy and clarity of steps used in verifying evidence	**Formative Criteria:** Discipline, perseverance and activeness **Sumative Criteria:** Case Studies (10) dinilai dengan rubrik 01 **Assessment Technique:** Non Test	**Response and Tutorial:** Case Study (Case Study) 2X50 minutes		Metric space Some examples of metric spaces and non-metric spaces.	10
3-4	Students understand and are able to explain the definition of open, closed and surrounding sets in metric space, and are able to prove that metric space is a topological space. (CPMK-1, CPMK-4)	**Formative:** Discipline, Liveliness, Tanya short answer. **Sumative:** Precision and clarity in using the definitions of open sets, environments and sets cap on metric space. Clarity and accuracy in proving metric spaces are topological spaces.	**Formative Criteria:** Discipline, perseverance and activeness dinilai dengan rubrik 04 **Sumative Criteria:** Case Studies (10) dinilai dengan rubrik 01 **Assessment Technique:** Test	**Studying:** Case Study (Case Study) 3X50 minutes		Open set, closed set and surroundings in space metrics. Metric space as topology space.	10

5-6	Students are able to prove the completeness of R^n, C^n, l^p, and L^p in metric spaces, as well as prove theorems related to the completeness of metric spaces. (CPMK-1, CPMK-4)	**Formative:** Gagal diterjemahkan **Sumative:** Precision and clarity in proving completeness in metric spaces Complete work and group cohesion.	**Formative Criteria:** Discipline, perseverance and activeness **Sumative Criteria:** Case Studies (10) dinilai dengan rubrik 01 **Assessment Technique:** Non Test	**Studying:** Case Study (Case Study) Students look for cases in the form of spaces that have metrics defined in them, then proven complete in metric space. This task is carried out in groups. TM: 3x3x50; PT: 3x3x60; BM: 3x3x50;		Convergent Sequence, sequence Cauchy Metric space completeness, space completeness theorems metric.	10
7	Students are able to prove Cauchy Schwarz inequality, Holder inequality, and Minskowski inequality (CPMK-1, CPMK-2)	**Formative:** Discipline, Liveliness, Tanya short answer. **Sumative:** Precision and clarity in using the convergent sequence definition and Cauchy sequence in proving completeness on metric spaces Completion work and group cohesiveness.	**Formative Criteria:** Discipline, perseverance and activeness dinilai dengan rubrik 04 **Sumative Criteria:** Case Studies (10) dinilai dengan rubrik 01 **Assessment Technique:** Non Test			Cauchy Schwarz inequality, Holder inequality, and inequality Minskowski.	10

8	Students are able to provide examples of incomplete spaces in metric space. (CPMK-1, CPMK-4)	**Formative:** Discipline, Liveliness, Tanya short answer. **Sumative:** Accuracy and clarity of steps used in carrying out verification proof. Complete work and group cohesion	**Formative Criteria:** Discipline, perseverance and activeness dinilai dengan rubrik 04 **Sumative Criteria:** Case Studies (10) dinilai dengan rubrik 01 **Assessment Technique:** Test	**Studying:** Group discussion (Small Group Discussion) 2X50 minutes **Studying:** Case Study (Case Study) Students look for cases in the form of spaces which are then proven to be incomplete in metric spaces. This task is carried out in groups. TM: 3x3x50; PT: 3x3x60; BM: 3x3x50.		.- Completeness in Metric space - Examples of incomplete spaces in metric spaces	10
9-12	Able to explain the concept of convergent sequences and Cauchy sequences in normed spaces and be able to prove that R^n, C^n, l^p, L^p and the continuous space C[a,b] are Banach spaces. (CPMK-4, CPMK-2)	**Formative:** Discipline, Liveliness, Tanya short answer. **Sumative:** able to prove that R^n, C^n, l^p, L^p and continuous space C[a,b] are Norm & Banach Room	**Formative Criteria:** Discipline, perseverance and activeness dinilai dengan rubrik 04 **Sumative Criteria:** Independent Assignment (25) dinilai dengan rubrik 01 **Assessment Technique:** Test	**Studying:** Self-Directed Learning 2X50 minutes		.Convergent Sequence, cauchy sequence in space norm - Banach Space - Some norm space which is a Banach space	25

13-14	Be able to explain the meaning of norm equivalence, and be able to prove that every norm in finite dimensional space is equivalent (CPMK-3)	**Formative:** Discipline, Liveliness, Tanya short answer. **Sumative:** Accuracy of the description of the concept of norm equivalence, Accuracy and clarity of steps used in verifying evidence, ability work together	**Formative Criteria:** Discipline, perseverance and activeness dinilai dengan rubrik 04 **Sumative Criteria:** Written Exam (10) dinilai dengan rubrik 01 **Assessment Technique:** Non Test	**Studying:** Case Study (Case Study) 3X50 minutes		Norm Spaces and subspaces in Finite Dimensions - Equivalence norms	10
15-16	Able to explain the meaning of Compact Sets, able to prove Riesz's Lema (CPMK-3)	**Formative:** Discipline, Liveliness, Tanya short answer. **Sumative:** Accuracy of the description of the concept of compact sets, Accuracy and clarity of steps used in verifying evidence, capabilities work together	**Formative Criteria:** Discipline, perseverance and activeness dinilai dengan rubrik 04 **Sumative Criteria:** Written Exam (15) dinilai dengan rubrik 01 **Assessment Technique:** Non Test	**Studying:** Discovery Learning 2X50 minutes		.-Compact Set and dimensions until	15
							100

Matrix of SLO, CLO, and Assessment Method

SLO / CLO	CLO-1	CLO-2	CLO-3	CLO-4
CPL-2 (P2)	Case Studies (Weight 10%) Case Studies (Weight 10%) Case Studies (Weight 10%) Case Studies (Weight 10%) Case Studies (Weight 10%)	Case Studies (Weight 10%) Independent Assignment (Weight 25%)		
CPL-4 (KU2)			Written Exam (Weight 10%) Written Exam (Weight 15%)	
CPL-7 (KK3)				Case Studies (Weight 10%) Case Studies (Weight 10%) Case Studies (Weight 10%) Independent Assignment (Weight 25%)

Evaluation Type and Assessment Weight

Type	Assessment Weight
Case Studies	50
Independent Assignment	25
Written Exam	10
Written Exam	15
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
			Formative	Sumative						
				Case Studies	Independent Assignment	Written Exam	Written Exam			
SLO-2	CLO-1	SUB-CLO-1	Discipline, perseverance and activeness	10	0	0	0	10		
SLO-7	CLO-4	SUB-CLO-2	Discipline, perseverance and activeness	10	0	0	0	10		
SLO-2	CLO-2	SUB-CLO-3	Discipline, perseverance and activeness	10	0	0	0	10		
SLO-7	CLO-4	SUB-CLO-4	Discipline, perseverance and activeness	10	0	0	0	10		
SLO-7	CLO-4	SUB-CLO-5	Discipline, perseverance and activeness	10	0	0	0	10		
SLO-2	CLO-2	SUB-CLO-7	Discipline, perseverance and activeness	0	25	0	0	25		
SLO-4	CLO-3	SUB-CLO-8	Discipline, perseverance and activeness	0	0	10	0	10		
SLO-4	CLO-3	SUB-CLO-9	Discipline, perseverance and activeness	0	0	0	15	15		
				50	25	10	15	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