QF01/0408-4.0E	Course Plan for Master program - Study Plan Development and Updating Procedures/ Mathematics Department

Study plan No.	**2021/2022**		**University Specialization**	**Master of Math.**	
Course No.	**0101712**		**Course name**	**Functional Analysis**	
Credit Hours	**3**		**Prerequisite/ Co-requisite**	**None**	
Course type	☐ MANDATORY UNIVERSITY REQUIREMENT	☐ UNIVERSITY ELECTIVE REQUIREMENTS	☐ FACULTY MANDATORY REQUIREMENT	☐ Support course family requirements	Mandatory requirements	✓ **Elective requirements**
Teaching style	☐ Full online learning		☐**Blended learning**		☐ **Traditional learning**	
Teaching model	☐ 1 Synchronous: 1 asynchronous		✓**2 face to face : 1 asynchronous**		☐ **2 Traditional**	

Faculty member and study divisions' information (to be filled in each semester by the subject instructor)

Name	Academic rank	Office No.	Phone No.	E-mail	
Division number	**Time**	**Place**	**Number of students**	**Teaching style**	**Approved model**

Brief description

Metric Space, Normed Space, Hilbert spaces, the geometry of Hilbert spaces, the Riesz representation theorem, orthonormal bases, isomorphic Hilbert spaces, operators on Hilbert space: adjoints, projections, invariant and reducing subspaces, positive operators and the polar decomposition, selfadjoint operators, normal operators, isometric and unitary operators, the spectrum and the numerical range of an operator, operator inequalities, compact operators, basics of Banach spaces especially commutative ones, convex sets and the Krein-Milman theorem, subspaces and quotient spaces, linear functionals and the dual spaces, the Hahn-Banach theorem in all its various forms, the uniform boundedness principle, the open mapping theorem, and the closed graph theorem.

Learning resources

Course book information (Title, author, date of issue, publisher ... etc)	1. E. Kreyszig, Introductory Functional Analysis with Applications, Wiley, New York, 1980. 2. J.B. Conway , A Course in Functional Analysis, 2nd ed., Springer-Verlag, New York, 1990.			
Supportive learning resources (Books, databases, periodicals, software, applications, others)	3. I. Gohberg and S. Goldberg, Basic Operator Theory, Birkhauser, Boston, 1981. 4. C.W. Groetsch, Elements of Applicable Functional Analysis, Dekker, New York, 1980. 5. A.E. Taylor and D.C. Lay, Introduction to Functional Analysis, 2nd ed., Wiley, New York, 1980.			
Supporting websites				
The physical environment for teaching	✓ Class room	☐ labs	✓ Virtual educational platform	☐ Others
Necessary equipment and software				
Supporting people				

with special needs	
For technical support	

No.	Course learning outcomes	The associated program learning output code
	Knowledge	
K1	Identify the basic facts about metric space, normed linear spaces and inner product spaces.	**MK 1**
K2	Differentiate between metric space, normed linear spaces and inner product spaces.	**MK 1**
K3	Analyze the basic concepts of Banach spaces and Hilbert spaces	**MK 2**
K4	State the definition and properties of continuous linear operator as well as functionals and duality.	**MK 2**
	Skills	
S1	Transfer the definition and relation between metric space, normed space, and inner product spaces.	**MS 1**
S2	Illustrate the facts about bounded linear functionals and bounded linear operators.	**MS 1**
S3	Describe some applications of Orthogonal, Hahn-Banach Theorem	**MS 2**
	Competences	
C1	Using analysis to solve various problems in all branches of mathematics	**MC 1**
C2	Be able to think in mathematical analysis.	**MC 2**

Mechanisms for direct evaluation of learning outcomes

Type of assessment / learning style	Fully electronic learning	Blended learning	Traditional Learning (Theory Learning)	Traditional Learning (Practical Learning)
Midterm exam	30%	**30%**	40%	30%
Participation / practical applications	0	**0**	10%	30%
Asynchronous interactive activities	30%	**30%**	0	0
Final exam	40%	**40%**	50%	40%

Schedule of simultaneous / face-to-face encounters and their topics

Week	Subject	learning style*	Reference **
1	Metric Space Further Examples of Metric Spaces	Lecture	1-16
2	Open Set, Closed Set, Neighborhood Convergence, Cauchy Sequence, Completeness	Lecture	17-31
3	Examples. Completeness Proofs Completion of Metric Spaces	Lecture	32-48
4	Vector Space Normed Space. Banach Space	Lecture	49-66
5	Further Properties of Normed Spaces Finite Dimensional Normed Spaces and Subspaces	Lecture	67-81
6	Linear Operators	Lecture	82-90

	Compactness and Finite Dimension		
7	Bounded and Continuous Linear Operators Linear Functionals	Lecture	91-110
8	Linear Operators and Functionals on Finite Dimensional Spaces Normed Spaces of Operators. Dual Space **Mid Exam 30%**	Lecture	111-126
9	Inner Product Space. Hilbert Space Further Properties of Inner Product Spaces	Lecture	127-141
10	Orthogonal Complements and Direct Sums Orthonormal Sets and Sequences	Lecture	142-159
11	Series Related to Orthonormal Sequences and Sets Total Orthonormal Sets and Sequences	Lecture	160-174
12	Legendre, Hermite and Laguerre Polynomials Representation of Functionals on Hilbert Spaces	Lecture	175-194
13	Second Exam 20% Hilbert-Adjoint Operator Self-Adjoint, Unitary and Normal Operators	Lecture	195-209
14	Zorn's Lemma Hahn-Banach Theorem	Lecture	210-230
15	Adjoint Operator Reflexive Spaces Strong and Weak Convergence Convergence of Sequences of Operators and Functionals	Lecture	231-270
16	**Final Exam 50%**		

Schedule of asynchronous interactive activities (in the case of e-learning and blended learning)

Week	Task / activity	Reference	Expected results
1	Background	Real Analysis 1	Self-reading and Discussion
2	Video 1 Solving exercises	E-learning	Discussion in the class
3	Home work1: On the subjects studied on the first three weeks	(Lecture notes and Ref.1)	Submit a pdf or word sheet
4	Quiz 1	On the subjects studied on the first three weeks	Submitting on the E-learning
5	Assignment 1	Internet sources and the other Supportive learning resources	Presentation
6	Video 2	Solving exercises	Discussion in the class
7	Home work 2 On the subjects studied in the weeks 4,5 and 6	(Lecture notes and Ref.1)	Submit a pdf or word sheet
8	Assignment 2	Internet sources and the other Supportive learning resources	Submitted with the mid exam
9	Self-reading for selected topic	(Ref.2)	Talk
10	Video3 Solving exercises	E-learning	Discussion in the class
11	Home work 3: On the subjects studied after the Midterm exam	(Lecture notes and Ref.1)	Submit a pdf or word sheet
12	Self-reading for selected topic	(Ref.2)	Talk
13	Quiz 2	On the subjects studied on the subject studied after Midterm	Submitting on the E-learning

		exam	
14	Presentation of the selected subject	Internet sources and the reference book	Video
15	Video 4 Revision of all the course	E-learning	
16	**Final Exam**	-	