UNIVERSITAS GADJAH MADA
Faculty of Mathematics and Natural Sciences
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MODULE HANDBOOK

Module Name	*Topics in Functional Analysis*
Module level, if applicable	*Doctor*
Code, if applicable	*MMM-7107*
Subtitle, if applicable	-
Semester(s) in which the module is taught	*1st or 2nd semester*
Person responsible for the module	*Chair of the Lab. Of Analysis*
Language	*Bahasa Indonesia*
Relation to curriculum	*Elective course in the 1st or 2nd semester of doctor's degree*
Teaching methods	*Lecture, classroom discussion, flipped classroom.*
Workload (incl. contact hours, self-study hours)	*Total workload is 232 hours per semester, which consists of 50 minutes lectures per week, 120 minutes structured activities per week, 120 minutes individual study per week, in total is 16 weeks per semester, including mid exam and final exam.*
Credit points in Credit Units	*3*
Required and recommended prerequisites for joining the module	*Students have strong knowledge on abstract analysis and on theory in algebra, especially vector space, linear independence set, and orthonormal basis.*
Module objectives/intended learning outcomes	*After completing this course, the students should have the ability to:* *CO 1 integrate one or more theories in functional analysis for the development in developing and solving problems with functional analysis approach* *CO 2 justify properties which are important in mathematical analysis research*

<table>
<tr><td>Content</td><td>
1. General functional analysis: Hilbert spaces, normed spaces, Riesz representation theorem, bilinear and sesquilinear mappings, adjoint, and spectral theorem.
2. Fuzzy functional analysis: fuzzy number and its characteristics, inequality, fuzzy Banach space or fuzzy metric space, continuous t-norms, open mapping theorem.
3. Operator theory: Preview on Hilbert spaces. Linear operator and adjoints: basic notion, bounded linear operators/functionals, isometry and isomorphism, adjoint operators, Banach-Steinhaus' Theorem, Strong and Weak convergent, projections. Closed linear operators: closed and closable operators, Closed Graph Theorem. Theory of Spectral, symmetry and self-adjoint operators, normal operators.
</td></tr>
<tr><td>Examination forms</td><td>Oral presentation, essay.</td></tr>
<tr><td>Study and examination requirements</td><td>
The final mark will be weighted as follows:
<table>
<tr><th>No</th><th>Assessment methods (components, activites)</th><th>Weight (percentage)</th></tr>
<tr><td>1</td><td>Final Examination : final project/presentation/oral exam/essay</td><td>30-40%</td></tr>
<tr><td>2</td><td>Mid-Term Examination : presentation/oral exam/essay</td><td>30-40%</td></tr>
<tr><td>3</td><td>Class Activities: presentation, quiz, homework, etc.</td><td>20-30%</td></tr>
</table>
To pass the course, students are expected to get a minimum grade of B.
</td></tr>
<tr><td>Media employed</td><td>Board, LCD Projector, Laptop/Computer</td></tr>
<tr><td>Reading list</td><td>

1. Berberian, S.K., 1999, Introduction to Hilbert space Vol. 287. American Mathematical Soc.
2. Kreyszig, E., 1991. Introductory Functional Analysis with Applications (Vol. 17). John Wiley & Sons.
3. Bachman, G. and Narici, L., 1998, Functional Analysis 2nd Edition, Dover Publications.
4. R. Saadati and S. M. Vaezpour, 2005, Some Results on Fuzzy Banach Spaces, J. Appl. Math. & Computing Vol. 17(2005), No. 1 - 2, pp. 475 - 484
5. Weidmann, J., 1980, Linear Operators in Hilbert Spaces, Springer-Verlag, New York.
6. Conway, J.B., 2019, A Course in Functional Analysis 3rd Ediiton, Springer Verlag, New York.
7. Taylor, A.E., 1980, Introduction to Functional Analysis, John Wiley and Sons, New York.

</td></tr>
</table>

CO-PLO Mapping

	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6

CO 1	**v**	**v**	**v**		**v**	**v**
CO 2	**v**	**v**	**v**		**v**	**v**

Last Modified Date : 08 August 2022

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MODULE HANDBOOK

Module designation	*Topics in Functional Analysis*
Code, if applicable	*MMM-7107*
Subtitle, if applicable	*Functional Analysis*
Semester(s) in which the module is taught	*1st or 2nd semester*
Person responsible for the module	*Chair of the Lab. of Analysis*
Language	*Bahasa Indonesia*
Relation to curriculum	*Elective course in the 1 st or 2 nd semester of doctor's degree*
Teaching methods	*Lecture, classroom discussion, flipped classroom.*
Workload (incl. contact hours, self-study hours)	*Total workload is 232 hours per semester, which consists of 50 minutes lectures per week, 120 minutes structured activities per week, 120 minutes individual study per week, in total is 16 weeks per semester, including mid exam and final exam.*
Credit points in Credit Units	*3*
Required and recommended prerequisites for joining the module	*Students have strong knowledge of abstract analysis and algebra theory, especially vector space, linear independence set, and orthonormal basis.*
Module objectives/intended learning outcomes	*After completing this course, the students should have the ability to:* *CO 1 integrate one or more theories in functional analysis for the development in developing and solving problems with functional analysis approach* *CO 2 justify properties that are important in mathematical analysis research*

Content	1. *Banach space: definition of Banach space, continuous linear mapping and its norm, dual space.* 2. *Hilbert space: definition of Hilbert space, orthonormal basis, separable space, Riesz representation theorem.* 3. *Operators in Hilbert space: bilinear and sesquilinear mappings, adjoint of an operator, some types of operators (adjoint operator, projection operator, isometric operator, unitary operator, normal operator), invariant and reducing space.* 4. *Spectral Theorem: proper value, approximate proper value, cc-operator, spectral theorem of normal operator.*
Examination forms	*e.g. report, manuscript, oral presentation, essay, etc.*
Study and examination requirements	*The final mark will be weighted as follows:* *No* — *Assessment methods (components, activities)* — *Weight (percentage)* *1* — *Final Examination: final project/presentation/oral exam/essay* — *30-40%* *2* — *Mid-Term Examination: presentation/oral exam/essay* — *30-40%* *3* — *presentation* — *20-30%* *To pass the course, the minimum grade is B.*
Reading list	1. *Berberian, S.K., 1999, Introduction to Hilbert space Vol. 287. American Mathematical Soc.* 2. *Kreyszig, E., 1991. Introductory Functional Analysis with Applications (Vol. 17). John Wiley & Sons.* 3. *Bachman, G. and Narici, L., 1998, Functional Analysis 2 nd Edition, Dover Publications.*

CO-PLO Mapping

	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6
CO 1	v	v	v		v	v
CO 2	v	v	v		v	v

Last Modified Date : September 3, 2023

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MODULE HANDBOOK

Module designation	*Topics in Functional Analysis*
Code, if applicable	*MMM-7107*
Subtitle, if applicable	*Operator Theory*
Semester(s) in which the module is taught	*1st or 2nd semester*
Person responsible for the module	*Chair of the Lab. Of Analysis*
Language	*Bahasa Indonesia*
Relation to curriculum	*Elective course in the 1st or 2nd semester of doctor's degree*
Teaching methods	*Lecture, classroom discussion, flipped classroom.*
Workload (incl. contact hours, self-study hours)	*Total workload is 232 hours per semester, which consists of 50 minutes lectures per week, 120 minutes structured activities per week, 120 minutes individual study per week, in total is 16 weeks per semester, including mid exam and final exam.*
Credit points in Credit Units	*3*
Required and recommended prerequisites for joining the module	*Students have strong knowledge on abstract analysis and on theory in algebra, especially vector space, linear independence set, and orthonormal basis.*
Module objectives/intended learning outcomes	*After completing this course, the students should have the ability to:* *CO 1 integrate one or more theories in operator theory.* *CO 2 justify properties which are important in mathematical analysis research*

Content	*Operator theory: Preview on Hilbert spaces. Linear operator and adjoints: basic notion, bounded linear operators/functionals, isometry and isomorphism, adjoint operators, Banach-Steinhaus' Theorem, Strong and Weak convergent, projections. Closed linear operators: closed and closable operators, Closed Graph Theorem. Theory of Spectral, symmetry and self-adjoint operators, normal operators.*
Examination forms	*Oral presentation, essay.*
Study and examination requirements	*The final mark will be weighted as follows:* *No* — *Assessment methods (components, activites)* — *Weight (percentage)* *1* — *Final Examination : final project/presentation/oral exam/essay* — *30-40%* *2* — *Mid-Term Examination : presentation/oral exam/essay* — *30-40%* *3* — *Class Activities: presentation, quiz, homework, etc.* — *20-30%* *To pass the course, students are expected to get a minimum grade of B.*
Reading list	1. *Weidmann, J., 1980, Linear Operators in Hilbert Spaces, Springer-Verlag, New York.* 2. *Conway, J.B., 2019, A Course in Functional Analysis 3rd Ediiton, Springer Verlag, New York.*

CO-PLO Mapping

	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6
CO 1	v	v	v		v	v
CO 2	v	v	v		v	v

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Last Modified Date:
September 04, 2023.

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MODULE HANDBOOK

Module Name	*Topics in Functional Analysis*
Code, if applicable	*MMM-7107*
Subtitle, if applicable	*Fuzzy functional analysis*
Semester(s) in which the module is taught	*1st or 2nd semester*
Person responsible for the module	*Chair of the Lab. Of Analysis*
Language	*Bahasa Indonesia*
Relation to curriculum	*Elective course in the 1st or 2nd semester of doctor's degree*
Teaching methods	*Lecture, classroom discussion, flipped classroom, project*
Workload (incl. contact hours, self-study hours)	*Total workload is 232 hours per semester, which consists of 50 minutes lectures per week, 120 minutes structured activities per week, 120 minutes individual study per week, in total is 16 weeks per semester, including mid exam and final exam.*
Credit points in Credit Units	*3*
Required and recommended prerequisites for joining the module	*Students have strong knowledge on abstract analysis and on theory in algebra, especially vector space, linear independence set, and orthonormal basis.*
Module objectives/intended learning outcomes	*After completing this course, the students should have the ability to:* *CO 1 justify properties that are important in fuzzy mathematical analysis research* *CO 2 Integrate one or more theories in fuzzy functional analysis in developing and solving problems with a fuzzy functional analysis approach*

Content	*Fuzzy functional analysis: fuzzy number and its characteristics, inequality, fuzzy Banach space or fuzzy metric space, continuous t-norms, open mapping theorem.*
Examination forms	*Oral presentation, essay/writing a report.*
Study and examination requirements	*The final mark will be weighted as follows:* *No* — *Assessment methods (components, activites)* — *Weight (percentage)* *1* — *Final Examination : final project/presentation/oral exam/essay* — *30-40%* *2* — *Mid-Term Examination : presentation/oral exam/essay* — *30-40%* *3* — *Class Activities: presentation, quiz, homework, etc.* — *20-30%* *To pass the course, students are expected to get a minimum grade of B.*
Media employed	*Board, LCD Projector, Laptop/Computer*
Reading list	1. *Zadeh, L.A. and Aliev, R.A.;, 2018, Fuzzy Logic Theory and Applications, World Scientific Book.* 2. *Diamond, P. and Kloeden, P., 1994, Metric Spaces of Fuzzy Sets: Theory and Applications, World Scientific Book.* 3. *Cho, Y.J., Rassias, and T.M., Saadati, R., 2018. Fuzzy Normed Spaces and Fuzzy Metric Spaces, Springer Cham.* 4. *R. Saadati and S. M. Vaezpour, 2005, Some Results on Fuzzy Banach Spaces, J. Appl. Math. & Computing Vol. 17(2005), No. 1 - 2, pp. 475 – 484* 5. *Berberian, S.K., 1999, Introduction to Hilbert space Vol. 287, American Mathematical Soc.* 6. *Conway, J.B., 2019, A Course in Functional Analysis 3rd Edition, Springer Verlag, New York.*

CO-PLO Mapping

	PLO 1	PLO 2	PLO 3	PLO 4	PLO 5	PLO 6
CO 1	v	v	v		v	v
CO 2	v	v	v		v	v

Last Modified Date : 4 September 2023