SYLLABUS

Course Code	*Course Num.*	*Course Name*	*Credit Hours*	*Lec.*	*Lab.*	*Tut.*	*Private study*	*Pre-requisites*	*Course Level*	*Teaching Language*
MAT	**615**	**Applied Functional Analysis**	**4**	**3**	**0**	**1**	**9**		**2^1-2^2**	**English**

[1] *Level 1, Year 2 for the M.Sc. in Mathematics*
[2] *Level 2, Year 2 for the M.Sc. in Mathematics*

A. Course Description

This course describes the most important ideas and theoretical results of Functional Analysis in order to introduce the Sobolev space $H^1(\Omega)$ with applications to some linear PDEs. The main topics of this course are the measure, integration, the Hilbert space $L^2(\Omega)$ properties, and the distribution theory. Of particular importance is also the notion of weak derivative to define the Hilbert space $H^1(\Omega)$ and to set up adequately some Dirichlet and Neumann BVPs formulations for simple linear PDEs.

B. Course Outcomes

At the end of this course the student will be able to:

1. Know the Hilbert space $L^2(\Omega)$ together with its main properties and weak convergence.
2. Define the Sobolev space $H^1(\Omega)$, where Ω is an open subset of the real line.
3. Review the fundamentals on test functions and distribution theory as well as the calculus on distributions including convergence of distributions.
4. Show how the functional setting of the Sobolev space $H^1(\Omega)$ can be used to derive some variational formulations for some one-dimensional linear partial differential equations.

C. References:

Required Textbook

1. **H. Brezis,** *Functional Analysis, Sobolev Spaces, and Partial Differential Equations*, Springer, 2010 (Main reference).

Other references:

2. **L.C. Evans,** *Partial Differential Equations*; 2nd Edition, American Mathematical Society, 2010.
3. **J.J. Duistermaat, J.A.C. Kolk,** *Distributions*: Theory and Applications, Springer, 2006.
4. **F. Hirsch, G. Lacombes,** *Elements of Functional Analysis*, Springer, 1999.

Course Website: Google Classroom Webpage:http://www.imamm.org/

D. Topics Outline

1. **The Hilbert space $L^2(I)$, $I \sqsubseteq R$**: Basic properties, Cauchy-Schwarz inequality, convergence in norm. Riesz-Fisher Theorem and the Hilbert space L^2. Riesz-Frechet Representation Theorem and reflexivity, Convolution and regularization. Separability.
2. **Review of Distribution Theory:** The space $\mathbf{D}(\Omega)$ of test functions, $\Omega \sqsubseteq R$, Support of a distribution, Regularization and approximation, Derivative of a distribution. The space $\mathbf{D}'(\Omega)$ of distributions**:** Calculus on distributions, Antiderivative of a distribution, Convergence of distributions. Applications: Fundamental solutions of some ODEs.
3. **The Sobolev space $H^1(\Omega)$, $\Omega \sqsubseteq R$**: Definitions and main properties. Mollifiers and density theorems. Sobolev imbedding theorems. Product, composition, and differentiation in $H^1(\Omega)$. Trace operator and the space $H_0^1(\Omega)$. The dual space $H^{-1}(\Omega)$: Definitions and properties, Poincare-Wirtinger inequality.
4. **Variational Formulation of linear BVPs:** Linear PDEs for Laplacian operator. Lax-Milgram Theorem, Weak solution, Classical solution, Maximum principle.

E. Office Hours

Office hours give students the opportunity to ask in-depth questions and to explore points of confusion or interest that cannot be fully addressed in class.

F. Exams & Grading System

The semi-official dates of the exams for this course are:

- **Midterm :** 8th or 9th week.
- **Quizzes & Homeworks:** During the semester.
- **Final Exam:** 16th week.

Your course grade will be based on your semester work as follows:

Midterm : 30 %	**Final Exam:** 40 %
Quizzes, Homework, Attendance & Participation: 30 %	

The grading distribution:

A^+	A	B^+	B	C^+	C	F
[95, 100]	[90, 95)	[85, 90)	[80, 85)	[75, 80)	[70, 75)	[0, 70)

G. Student Attendance/Absence

Only three situations will be considered as possible excused absences:

- Occurrence of a birth or death in the immediate family will be excused. ("Immediate family" is defined by the University as spouse, grandparents, parents, brother, or sister).
- Severe illness in which a student is under the care of a doctor and physically unable to attend class will be excused. Students are not excused for a doctor's appointment. Do not make appointments that conflict with rehearsals. Notes from the University Health Center will be accepted.

Executive Rules for Study Regulations and Examsgoo.gl/ykm7t3

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