**THE UNIVERSITY OF TEXAS AT EL PASO**
**COLLEGE OF SCIENCE**
DEPARTMENT OF Mathematical Sciences

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| **Course #:** | 28345 |
| **Course Title:** | Introduction to Applied Analysis (Math 5309) |
| **Credit Hrs:** | 3 |
| **Term:** | Spring 2019 |
| **Course Meetings &** | MW, 4:30-5:50 PM |
| **Location:** | Bell Hall 130A |
| **Prerequisite Courses:** | Math 3341 and Math 3323 are required. Math 5321/4341 and Math 4326 is desirable. |
| **Course Fee: (if applicable)** | |
| **Instructor:** | Dr. B. D. Rouhani |
| **Office Location:** | Bell Hall 327 |
| **Contact Info:** | Phone # 747-6767<br>E-mail address: behzad@utep.edu<br>Fax # 747-6502<br>Emergency Contact |
| **Office Hrs:** | MW, 3:00-4:00 PM, and by appointment. |
| **Textbook(s), Materials:** | Required: E. Kreyszig, Introductory Functional Analysis with Applications, Wiley Classics Library Edition, 1989, John Wiley & Sons, New York. ISBN 0-471-50459-9 (pbk).<br>E. Zeidler, Applied Functional Analysis, 2 Vols., Springer, 1995.<br><br>Suggested: H. Brezis, Functional Analysis, Sobolev Spaces and Partial Differential Equations, Springer 2011.<br>Additional references will be given during the course, and some (including the above) will be put on reference in the library's reference desk for the students' use. |
| **Course Objectives (Learning Outcomes):** | The main objectives of this course include showing the students how some abstract and powerful theorems of Analysis can be applied to more concrete and practical problems in differential and integral equations, calculus of variations, partial differential equations and optimization arising from problems in engineering, physical and social sciences. By following a rigorous approach to these problems, by the end of the course the students should be prepared to take more advanced courses of Analysis in Mathematics, as well as to apply the knowledge they acquired to more applied and concrete problems of Mathematics, Engineering, Physical and Social Sciences, and also be able to read research articles in their corresponding fields. |

**Course Activities/Assignments:**

The class is a student run class. Therefore besides the core lecture, as well as some computer demonstrations, the instructor will regularly ask questions to students who are expected and strongly encouraged to actively participate in the group discussions that will follow.
The instructor will regularly assign homework. It is essential for your success in this class that you diligently work all the homework problems. Homework will include reading assignments, as well as group projects.
It is expected that you spend an absolute minimum of six hours a week outside of class on solving homework problems, working on the lab assignments, reading the textbook and reviewing your class notes.

**Assessment of Course Objectives:**

Besides the group class discussions and the homework assignments that were mentioned above, students are expected to give presentations and/or work on (group) projects. The final exam will be a comprehensive oral exam.

**Course Schedule:**

After introducing some elements of Hilbert and Banach space theory, as well as some basic theorems of functional analysis, we will apply those concepts to more practical and applied problems. The choice is very vast, and may include topics from differential and integral equations, partial differential equations, game theory, calculus of variations, optimization, etc. The choice among the above material to be covered will be made according to the interests and background of the students participating in the class.
**See the appendix at the end, for a more detailed list of topics we will choose from them.**
**Some important dates in the class schedule are as follows:**
Monday, 1/21 is the Martin Luther King, Jr. Holiday. No classes.
Wednesday, 2/6 is the last day to drop without "W". (Census Day).
March 18-22 is the Spring Break. No classes.
Friday, March 29 is the Cesar Chavez Birthday Observance. No classes.
Friday, April 5, is the last day to drop with an automatic "W".
No class on 5/10 (Dead Day).
**Final Exam:** Monday, May 13, at 4:00 PM in Bell Hall 130A.

**(NOTE: Final exams must be given at the scheduled time; any/all exceptions must be approved by both the department chair and the dean.)**

**Notes: 1) The exact dates for the presentations by the students will be fixed and announced at least one week in advance.**
**2) The instructor will NOT assign a "W" for students dropping the course after the deadline.**
**3) Help: There is plenty of help available to you provided you are willing to take advantage of it.** Besides my office hours I will gladly meet with you on a drop in basis any time I am free to do so. Talk to me before or after class or by phone or by email to set up an appointment.

**Grading Policy:** The usual grading scale will be used for this course (90 or above corresponds to an A, 80 to 89 is a B, 70 to 79 is a C, 60 to 69 is a D, below 60 is an F).
Homework will count for 25%, active participation in class for 25%, presentations for 25%, and the comprehensive oral final exam will count for 25% of your final grade.

**Make-up Policy:** Make-ups will only be given under extraordinary circumstances (as determined by the instructor), and only if you notify the instructor prior to the due date.

**Attendance Policy:**

- Attendance to all classes is required; late arrivals are not allowed; more than three consecutive absences without prior notice or justification will result in the student's drop from the class list with an "F".

**Academic Integrity Policy:** See UTEP's policy cited in http://academics.utep.edu/Default.aspx?tabid=23785

**Civility Statement:** Active participation and teamwork is strongly encouraged; use of cell phone and talking during class, which results in the disruption of other students, are not allowed.

**Disability Statement:** **If you have a disability and need classroom accommodations, please contact The Center for Accommodations and Support Services (CASS) at 747-5148, or by email to cass@utep.edu, or visit their office located in UTEP Union East, Room 106. For additional information, please visit the CASS website at www.sa.utep.edu/cass.**

**Military Statement:** If you are a military student with the potential of being called to military service and /or training during the course of the semester, you are encouraged to contact me as soon as possible.

- ***General remark:***

  If you have problems with the course material, need to be absent, or have any other circumstance that may affect your performance in the course, contact me as soon as possible. I will do everything I can to enable you to succeed in this course and I expect you to be as diligent in your efforts as I am in mine.

***If you have any question, please send it to Dr. B.D. Rouhani via e-mail at behzad@utep.edu***

# Appendix

Topics will be chosen from the following:

I. Review of Topology and Integration.

Topological space, compact set, limit and continuity, metric space, Banach space, Hilbert space, convex function, lower semicontinuous function, Weierstrass Theorem. Some applications such as the Fundamental Theorem of Algebra, and Riesz' Theorem (characterization of finite dimensional normed spaces).
Brief overview of the main theorems of Lebesgue integration; monotone convergence theorem (Beppo Levi), Lebesgue's dominated convergence theorem, Fatou's lemma, Tonelli and Fubini's theorems, $L^p$ spaces, convolution.

II. Banach spaces and fixed point theorems.

Bounded linear operators, conjugate space, Banach fixed point theorem and Picard's iteration, applications to integral equations and ordinary differential equations (ODE)
Brouwer fixed point theorem, applications to Perron-Frobenius theorem and to periodic solutions of ODE. Schauder fixed point theorem, applications to integral equations and to ODE.

III. Hahn-Banach theorems (analytic and geometric forms), applications to optimization.
Uniform boundedness theorem and closed graph theorem with some applications.
Unbounded linear operators.

IV. Weak topologies, reflexive Banach spaces, variational principles, saddle points, applications to optimization and game theory.

V. Hilbert spaces. Definitions and elementary properties, nearest point projection on a closed convex set, conjugate space, Stampacchia and Lax-Milgram's theorems, Hilbert basis, Parseval identity.

VI. Compact operators, Riesz-Fredholm theory, applications to integral equations, spectral decomposition of compact self-adjoint operators.

VII. Generalized derivatives, Sobolev spaces, Dirichlet principle, applications to boundary value problems.

VIII. Maximal monotone operators, first order evolution equations, applications to the heat and wave equations.