MATH 8378 – 01

Inverse Problems and Image Reconstructions Syllabus for Spring 2025

**Classroom**: EMAGC 1.422

**Time:** M & W 12:30pm-1:45pm, January 21, 2025 – May 15, 2025

# Instructor:

Dr. Zhijun (George) Qiao

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**Office Hours**: Mondays & Wednesdays 2:00pm – 3:00pm or by appointment. Office location: EMAGC 3.722, or join Office Hours in person or through Zoom link: https://utrgv.zoom.us/j/2824166420

# Prerequisite:

A graduate student has completed and passed MATH 6378 or MATH 4344 (Boundary Value Problems or Partial Differential Equations) with a grade B or better or consent of instructor.

**Textbook:** Required book – Fundamentals of Radar Imaging, 2009, Author(s): Margaret Cheney Publisher: Society for Industrial and Applied Mathematics ISBN-13: 9780898716771.

Recommended books: 1) Lectures on the Fourier Transform & Its Applications, Author(s): Brad G. Osgood, Publisher: American Mathematical Society ISBN: 9781470441913, 2) Fourier Transforms in Radar and Signal Processing, David Brandwood, Artech House Publishers; 2nd ed. edition (November 30, 2011), ISBN-13: ‎ 978-1608071975.

**Software:** We will be using Mathematica or Matlab or Maple software. Most computer labs in the EMAGC building have Maple installed and Mathematica is available in all computer labs on campus. To install a copy of Mathematica on your own computer, follow instructions given here <http://faculty.utrgv.edu/andras.balogh/Students.html.> Maple has a built-in Differential Geometry package, however for Mathematica, you will need to download and install the xAct package for the necessary functionality: [http://www.xact.es/.](http://www.xact.es/) Use of LaTeX will be required for the final project.

# Topics:

1. Fourier Transforms and Preliminaries,
2. Inverse problem of linear PDEs,
3. Maxwell equation and Fourier integral operator,
4. Back-projection operator and applications in radar image reconstruction,
5. Synthetic aperture radar image,
6. Inverse synthetic aperture radar images arranged by antenna.
7. Reference reading and present for future research

**Course Description**: This course includes inverse problems of linear PDEs, Maxwell equation and Fourier integral operator, Back-projection operator and applications in radar image reconstruction, including synthetic aperture radar (SAR) image and inverse synthetic aperture radar images arranged by antenna. The students will learn Inversion of Fourier Integrable Operators, MIMO-SAR systems, and algorithm for moving targets. Most ISAR algorithms are described in detail to provide simulations for real world problems.

**Student Learning Outcomes**: After completing this course, students will

* Understand the terminology, scope, main results, and applications of mathematical signal and image processing and Fourier analysis.
* Be able to compute and apply Back-projection transforms, and use them to solve problems in mathematics, science, and engineering.
* Know terminology and results of synthetic aperture radar image and inverse synthetic aperture radar images arranged by antenna, such as functional analysis, and how they relate to engineering and physics problems.
* Understand wavelet analysis and multiresolution analysis and their applications.
* Know how to apply computer and graphing technology (software: Matlab, Maple or Mathematica) to gain insight into the topics discussed.

# General Grade Policy

**Homework and Projects –** Homework assignment is assigned every class day and will consist of problems and reading from the textbook and occasional handout. Projects are based on homework problems. A project will be taken ~ every month, namely, ~ 3 times in the whole semester. ***Projects will be designed in two formats: each student gives a presentation based on the homework, and the other is to solve some physical problems I will assign***. It is strongly recommended that students work on all those homework problems since projects score are used to determine your project grade. Completing the assignments is the ***single most important part*** of this course. You will be expected to spend on average, about 4 hours each week completing the assignments. The assigned problems will not be collected or graded, but they will form the basis for projects, midterm exams, and the final exam. I will select your best 2 of your project scores in final grade. No late re-project will be accepted.

**Tests –** There will be one 75-minute test. All test problems must be taken during their scheduled times. The test time will be announced in advance (basically, a test will be given every two topics or chapters), and a brief review will be given before each test. All students must show their work on the tests. Score will be provided to you separately. No re-test opportunities.

**Final Exam –** The comprehensive final exam has tentatively been scheduled, 10:15 AM – 12:00 PM 05/14/2025, Wednesday. All students must take the final exam at the scheduled time. A summary review will be given in the class before the final exam.

**Grading –** The course grade will be based on

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| --- | --- |
| Homework/Quizzes/Discussions | 50 pts |
| Best 2 out of 3 projects at 75 pts each | 150 pts |
| Midterm Test | 100 pts |
| Comprehensive Final Exam | 100 pts |
| Total | 400 pts |

The course grade will be assigned according to a scale no higher than A(85-100%), B(75- 84%), C(60-74%), F(below 60%).

## THERE WILL BE NO MAKE-UP EXAMS GIVEN.

If a student is absent during a scheduled major test and quiz, the student must go by the instructor’s office during the scheduled office hours to discuss the validity of the excuse. In the case of a valid excuse, the missed test grade will be replaced by the final exam grade. If a student does not have a valid excuse, the grade for the missed test is a zero and cannot be replaced. If you arrive late to a test you will not be given additional time to complete the exam. Anyone arriving to a test after somebody else who took the exam has left will not be allowed to take the exam. Students missing more than one exam may be dropped from the course. With an unexcused absence, a score of 0 will be recorded for the missed HW/Quiz or exam.

### Tutoring: you may use online resources as your own study for the homework problem solving.

***Classroom Behavior:***

* + All beepers and cellular phones must be turned off before you enter the classroom.
  + Once in class, a student is expected to remain in class for the duration of the class. If a student needs to leave class early, than the student needs to discuss the situation with the instructor before class begins.
  + During class students are expected to be courteous to the instructor and other classmates. Examples of discourteous behavior are unnecessary talking, sleeping, tardiness, leaving class while instructor is lecturing, sharpening pencils during the lecture, etc.
  + No Food Allowed In Classroom.
  + Chronic tardiness and discourteous behavior will not be tolerated and is cause for a student's dismissal from class for the remainder of the semester.

### UTRGV Policy Statements

UTRGV requires all electronic communication between the University and students be conducted through the official University supplied systems UTRGV-Mail. Please use your UTRGV-Mail account for all correspondence with me.

### Calculators, Cell Phones, and Other Electronic Equipment

Calculators will be permitted for use on exams. Electronic equipment such as cell phones, pocket organizers, tablet or laptop computers, or electronic writing pads or pen-input devices will not be permitted during exams. Please make sure that cell phones are turned off and stored way during class.

## MANDATORY COURSE EVALUATION PERIOD:

Students are required to complete an ONLINE evaluation of this course, accessed through your UTRGV account (*https://my.utrgv.edu/home*); you will be contacted through email with further

instructions. Students who complete their evaluations will have priority access to their grades. Online evaluations will be available: July 1 – 8 for summer I semester courses.

**ATTENDANCE:** Students are expected to attend all scheduled classes and may be dropped from the course for excessive absences. UTRGV’s attendance policy excuses students from attending class if they are participating in officially sponsored university activities, such as athletics; for observance of religious holy days; or for military service. Students should contact the instructor in advance of the excused absence and arrange to make up missed work or examinations.

## STUDENTS WITH DISABILITIES:

If you have a documented disability (physical, psychological, learning, or other disability which affects your academic performance) and would like to receive academic accommodations, please inform your instructor and contact Student Accessibility Services to schedule an appointment to initiate services. It is recommended that you schedule an appointment with Student Accessibility Services before classes start. However, accommodations can be provided at any time. **Brownsville Campus**: Student Accessibility Services is located in Cortez Hall Room 129 and can be contacted by phone at (956) 882-7374 (Voice) or via email at [ability@utrgv.edu.](mailto:ability@utrgv.edu) **Edinburg Campus:** Student Accessibility Services is located in 108 University Center and can be contacted by phone at (956) 665-7005 (Voice), (956) 665-3840 (Fax), or via email at [ability@utrgv.edu.](mailto:ability@utrgv.edu)

## SCHOLASTIC INTEGRITY:

As members of a community dedicated to Honesty, Integrity and Respect, students are reminded that those who engage in scholastic dishonesty are subject to disciplinary penalties, including the possibility of failure in the course and expulsion from the University. Scholastic dishonesty includes but is not limited to: cheating, plagiarism, and collusion; submission for credit of any work or materials that are attributable in whole or in part to another person; taking an examination for another person; any act designed to give unfair advantage to a student; or the attempt to commit such acts. Since scholastic dishonesty harms the individual, all students and the integrity of the University, policies on scholastic dishonesty will be strictly enforced (Board of Regents Rules and Regulations and UTRGV Academic Integrity Guidelines). All scholastic dishonesty incidents will be reported to the Dean of Students.

### SEXUAL HARASSMENT, DISCRIMINATION, and VIOLENCE:

In accordance with UT System regulations, your instructor is a “responsible employee” for reporting purposes under Title IX regulations and so must report any instance, occurring during a student’s time in college, of sexual assault, stalking, dating violence, domestic violence, or sexual harassment about which she/he becomes aware during this course through writing, discussion, or personal disclosure. More information can be found at [www.utrgv.edu/equity,](http://www.utrgv.edu/equity) including confidential resources available on campus. The faculty and staff of UTRGV actively strive to provide a learning, working, and living environment that promotes personal integrity, civility, and mutual respect in an environment free from sexual misconduct and discrimination.

**COURSE DROPS:** According to UTRGV policy, students may drop any class without penalty earning a grade of DR until the official drop date. Following that date, students must be assigned a letter grade and can no longer drop the class. Students considering dropping the class should be aware of the “3-peat rule” and the “6-drop” rule so they can recognize how dropped classes may affect their academic success. The 6-drop rule refers to Texas law that dictates that undergraduate students may not drop more than six courses during their undergraduate career. Courses dropped at other Texas public higher education institutions will count toward the six-course drop limit. The 3-peat rule refers to additional fees charged to students who take the same class for the third time.