Course Information

Course Number:	Math 689
Course Title:	Inverse Problems and Imaging
Section:	601
Time:	MW 12:45-2:00 pm
Location:	611
Credit Hours:	3

Instructor Details

Instructor:	Peter Kuchment
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Office Hours:	TBA

Course Description

Tomography (or computerized tomography, or computer assisted tomography) is a technology (in fact, a complex of different technologies) that enables one to see inside of a non-transparent body. Many of you have probably heard about CAT scanners currently available in most hospitals. CAT here stands for Computer Assisted Tomography. One can easily imagine that if such a technique is available, it is extremely useful in all kinds of applications, e.g. in medical diagnostics (search for tumors, lung diseases, etc.), non-destructive evaluation in industry (checking for interior cracks in materials), oil and water prospection, deep Earth geophysics imaging, and border inspection.
The crucial thing about tomography is that there is no ``film" there like in the case of X-ray pictures, so the final high quality images (we present some of them below) are the results of an intricate MATHEMATICAL procedure that belongs to the general area of **inverse problems.** Thus, we will address first the general notions, features, major problems, of and approaches to the latter.

The mathematics of inverse problems and imaging is extremely beautiful and diverse. It involves manifold techniques that are of general importance for mathematicians (either pure or applied), engineers (especially electrical engineers, biomedical engineers), physicists, and other scientists. Among these one can especially distinguish the so called Harmonic (or Fourier) Analysis, which is one of the most important ideas of the whole mathematics. As the name Harmonic Analysis suggests, it has some relations with music and sound propagation, but in fact it is of much more general significance for most of mathematics and for engineering topics like digital filtration, information transmission, heat conduction, and many others. Differential equations also play a significant role in most of the tomographic fields. Algebraic and computer programming aspects come into play as well.

New tomographic methods that require new engineering and mathematics solutions are being constantly developed (in parti, time permitting, cular at the mathematics, biomedical engineering, and nuclear engineering departments at TAMU). The class will touch upon various well established techniques (X-ray CAT scan, emission tomography, MRI, ultrasound imaging, etc.), as well as of those that are being developed (or improved) now (optical imaging, diffraction tomography, electrical impedance imaging, electron tomography, neutron tomography, hybrid methods such as thermo/photo-acoustic tomography). Some Matlab codes will be also written.

Course Prerequisites

Basic knowledge of PDEs, elements of functional analysis, operator theory and Fourier transform/series (the latter will be supplemented with a preparatory notes distributed)

Special Course Designation

Course Learning Outcomes

Textbook and/or Resource Materials **(More will follow)**

I will use a variety of sources (including the instructor's notes and probably some texts placed on reserve), so there is **no textbook required to be purchased**.
Here are some useful books:
1. T. Feeman, *The mathematics of medical imaging: a beginner's guide,* Springer 2009. **An undergraduate text about very basic stuff.**
2. P. Kuchment, *The Radon transform and medical imaging*, SIAM 2014. **Graduate level. The closest to the class.**
3. F. Natterer, *The mathematics of computerized tomography*, Wiley 1986. *Reprinted by SIAM in 2001*. **The classical excellent source. Rather terse writing but rewarding reading. Somewhat outdated.**

Grading Policy

Graded Class Attendance and Participation, possible non-obligatory (extra credit) assignments

Late Work Policy
- *NA*

Course Tentative (subject to change at instructor's discretion) Schedule

TBA

University Policies

This section outlines the university level policies that must be included in each course syllabus. The TAMU Faculty Senate established the wording of these policies.

NOTE: *Faculty members should not change the written statements. A faculty member may add separate paragraphs if additional information is needed.*

Attendance Policy

The university views class attendance and participation as an individual student responsibility. Students are expected to attend class and to complete all assignments.

Please refer to Student Rule 7 in its entirety for information about excused absences, including definitions, and related documentation and timelines.

Makeup Work Policy

Students will be excused from attending class on the day of a graded activity or when attendance contributes to a student's grade, for the reasons stated in Student Rule 7, or other reason deemed appropriate by the instructor.

Please refer to Student Rule 7 in its entirety for information about makeup work, including definitions, and related documentation and timelines.

Absences related to Title IX of the Education Amendments of 1972 may necessitate a period of more than 30 days for make-up work, and the timeframe for make-up work should be agreed upon by the student and instructor" (Student Rule 7, Section 7.4.1).

"The instructor is under no obligation to provide an opportunity for the student to make up work missed because of an unexcused absence" (Student Rule 7, Section 7.4.2).

Students who request an excused absence are expected to uphold the Aggie Honor Code and Student Conduct Code. (See Student Rule 24.)

Academic Integrity Statement and Policy

"An Aggie does not lie, cheat or steal, or tolerate those who do."

"Texas A&M University students are responsible for authenticating all work submitted to an instructor. If asked, students must be able to produce proof that the item submitted is indeed the work of that

student. Students must keep appropriate records at all times. The inability to authenticate one's work, should the instructor request it, may be sufficient grounds to initiate an academic misconduct case" ([Section 20.1.2.3, Student Rule 20](#)).

Texas A&M at College Station
You can learn more about the Aggie Honor System Office Rules and Procedures, academic integrity, and your rights and responsibilities at [aggiehonor.tamu.edu](#).

Americans with Disabilities Act (ADA) Policy

Texas A&M University is committed to providing equitable access to learning opportunities for all students. If you experience barriers to your education due to a disability or think you may have a disability, please contact the Disability Resources office on your campus (resources listed below) Disabilities may include, but are not limited to attentional, learning, mental health, sensory, physical, or chronic health conditions. All students are encouraged to discuss their disability related needs with Disability Resources and their instructors as soon as possible.

Texas A&M at College Station
Disability Resources is located in the Student Services Building or at (979) 845-1637 or visit [disability.tamu.edu](#).

Title IX and Statement on Limits to Confidentiality

Texas A&M University is committed to fostering a learning environment that is safe and productive for all. University policies and federal and state laws prohibit gender-based discrimination and sexual harassment, including sexual assault, sexual exploitation, domestic violence, dating violence, and stalking.

With the exception of some medical and mental health providers, all university employees (including full and part-time faculty, staff, paid graduate assistants, student workers, etc.) are Mandatory Reporters and must report to the Title IX Office if the employee experiences, observes, or becomes aware of an incident that meets the following conditions (see [University Rule 08.01.01.M1](#)):

- The incident is reasonably believed to be discrimination or harassment.
- The incident is alleged to have been committed by or against a person who, at the time of the incident, was (1) a student enrolled at the University or (2) an employee of the University.

Mandatory Reporters must file a report regardless of how the information comes to their attention – including but not limited to face-to-face conversations, a written class assignment or paper, class discussion, email, text, or social media post. Although Mandatory Reporters must file a report, in most instances, a person who is subjected to the alleged conduct will be able to control how the report is handled, including whether or not to pursue a formal investigation. The University's goal is to make sure you are aware of the range of options available to you and to ensure access to the resources you need.

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Students wishing to discuss concerns in a confidential setting are encouraged to make an appointment with [Counseling and Psychological Services](#) (CAPS).

Students can learn more about filing a report, accessing supportive resources, and navigating the Title IX investigation and resolution process on the University's [Title IX webpage](#).

Statement on Mental Health and Wellness

Texas A&M University recognizes that mental health and wellness are critical factors that influence a student's academic success and overall wellbeing. Students are encouraged to engage in healthy self-care by utilizing available resources and services on your campus

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Students who need someone to talk to can contact Counseling & Psychological Services (CAPS) or call the TAMU Helpline (979-845-2700) from 4:00 p.m. to 8:00 a.m. weekdays and 24 hours on weekends. 24-hour emergency help is also available through the 988 Suicide & Crisis Lifeline (988) or at [988lifeline.org](#) [Links to an external site.](#).

College and Department Policies

College and departmental units may establish their own policies and minimum syllabus requirements. As long as these policies and requirements do not contradict the university level requirements, colleges and departments can add them in this section. Please remove this section if not needed.