IMPORTANT: This syllabus form should be submitted to OAA (gsbs_academic_affairs@uth.tmc.edu) a week before the start of each semester.

NOTE to STUDENTS: If you need any accommodations related to attending/enrolling in this course, please contact one of the Graduate School's 504 Coordinator, Natalie Sirisaengtaksin, PhD. We ask that you notify GSBS in advance (preferably at least 3 days before the start of the semester) so we can make appropriate arrangements.

Term and Year: **Fall 2025** Course Number and Course Title: **GS02 1052: Imaging Science** **Credit Hours: 2** Prerequisites: **Calculus, Linear Algegra** Meeting Location: **MDACC** Building/Room#: **DI-FCT14.5059** WebEx/Zoom Link: **N/A**	Program Required Course: **Yes** Approval Code: **No** Audit Permitted: **Yes** Classes Begin: **August 29, 2025** Classes End: **December 12, 2025** Final Exam Week: **Dec. 8-12, 2025**

Class Meeting Schedule

Day	Time
Tuesday; Friday	**11am – 12pm**

Course Director Name and Degree: **David Fuentes, PhD** Title: **Associate Professor** Department: **Imaging Physics** Institution: **MDACC** Email Address: dtfuentes@mdanderson.org Contact Number: 7**13 745 3377** **Course Co-Director/s:** (if any) Name and Degree: **Dragan Mirkovic, PhD** Title: **Associate Professor** Department: **Radiation Physics** Institution: **MDACC** Email Address: dmirkovi@mdanderson.org	**Instructors** 1. **David Fuentes, PhD** Institution: MDACC Email Address: dtfuentes@mdanderson.org 2. **Dragan Mirkovic, PhD** Institution: MDACC Email Address: dmirkovi@mdanderson.org

Contact Number: 713-563-2643 **NOTE:** Office hours are available by request. Please email me to arrange a time to meet.	

Course Description: This course provides a concise and coherent review of some commonly-encountered topics in applied mathematics, with a particular emphasis on their applications and relevance to imaging science. The course covers and is equally divided into two major sections: (i) image analysis methods and (ii) Fourier and wavelet transforms. Our image analysis approach provides a formalism for image registration, image reconstruction, image segmentation, and machine learning.

Textbook/Supplemental Reading Materials (if any)

Jorge Nocedal and Stephen J. Wright. Numerical optimization, 2nd edition, Springer Verlag, 1999.
Ronald Bracewell, The Fourier transform and its applications, 3rd edition, McGraw Hill, 2000.
Michael Greenberg, Foundations of Applied Mathematics, Prentice Hall, 1978
E. Kreyszig, Introductory functional analysis with applications, volume 21. Wiley, 1989

Course Objective/s:
Upon successful completion of this course, students will possess a working knowledge of image analysis methods and transforms commonly encountered in research.

Specific Learning Objectives:

- Develop a mathematical formalism for approaching some commonly encountered problems in medical physics.
- Interpret multiple distance measures for identifying accurate solutions .
- Apply the mechanics of a neural network for image segmentation.
- Understand common computational techniques for solving optimization problems inherent to image registration and image reconstruction.
- Understand the mathematical formulation, properties, and limitations of Fourier transforms (continuous and discrete) and wavelet transforms and how they relate to some medical physics problems.

Student Responsibilities and Expectations:

Students enrolled in this course will be expected to perform the following activities each week.

1. Prepare homework assignments based on course lectures/ readings.
2. Participate in and contribute to course discussions during lecture, and review sessions
3. Prepare for and take a final examination based on the lecture and some reading material

While you may work and discuss all course materials and assignments in groups, all writing assignments must be your own. Cheating or engaging in unethical behavior during examinations (quizzes and final) will be grounds for dismissal from the course without credit and further GSBS disciplinary action.

Grading System: **Letter Grade (A-F)**	
Student Assessment and Grading Criteria : *(May include the following:)*	
Percentage	**Description**
Homework (40 %)	
Midterm Exams (30 %)	
Final Exam (30 %)	

CLASS SCHEDULE – Fall 2025

1 (8/29)	Fuentes	1. Preliminaries - Algorithm Complexity, BLAS
2 (9/2)	Fuentes	2. Vector and metric spaces
3 (9/5)	Fuentes	3. Mutual Information
4 (9/9)	Fuentes	4. Entropy
5 (9/12)	Fuentes	5. Linear Independence, Equivalence of Norms
6 (9/16)	Fuentes	6. Linear Operators, Convolution
7 (9/19)	Fuentes	7. Image Segmentation
8 (9/23)	Fuentes	8. Analysis of Neural Network Structure
9 (9/26)	Fuentes	9. Rank and Nullity, Bounded Operator, Stability of Linear Systems
10 (9/30)	Fuentes	10. Inner Product, Orthogonality, Eigen-formulation
11 (10/3)	Fuentes	11. Optimization Characterization of Solution
12 (10/7)	Fuentes	12. Line search, Newton-CG Trust-Region Methods
13 (10/10)	Fuentes	13. Least Square, QR Decomposition
14 (10/14)	Fuentes	14. L1 minimization
15 (10/17)	Fuentes	15. exam on optimization

16 (10/21)	Mirkovic	1. Where Nature does or calls for FT, definition of FT, notations, symmetry and FT, interpretation of FT
17 (10/24)	Mirkovic	2. Some useful functions and calculating their FT
18 (10/28)	Mirkovic	3. Convolution, correlations, the central limit theorem
19 (10/31)	Mirkovic	4. LTI systems, more on convolution, FT as a linear system, what's special about exp(-i2πxy)?
20 (11/4)	Mirkovic	5. Convolution theorem and other Fourier theorems
21 (11/7)	Mirkovic	6. The δ-function, distributions/generalized functions, re-defining FT
22 (11/11)	Mirkovic	7. Discrete Fourier Transform, cyclic convolution
23 (11/14)	Mirkovic	8. The Fast Fourier Transform algorithm
24 (11/18)	Mirkovic	9. The Sampling Theorem, ghost function, and Nyquist frequency
25 (11/21)	Mirkovic	10. Drawbacks of FT, wavelets, and continuous wavelet transforms, wavelet transform as a cross-correlation and constant-Q filtering
26 (11/25)	Mirkovic	11. Discrete wavelet transforms and orthogonal wavelet decomposition, multi-resolution analysis
27 (11/28)	Mirkovic	12. more on MRA, scaling function, digital filtering
28 (12/2)	Mirkovic	13. Haar wavelets, filters, filter banks, multistage filter banks, and perfect reconstruction
29 (12/5)	Mirkovic	14. Medical physics applications of Fourier and wavelet transforms
30 (TBD)	Mirkovic	15. Exam on transforms

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