**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.

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| Term and Year: **Spring 2026**<br><br>Course Number and Course Title:<br>**GS02 1032: Principles of Magnetic Resonance Imaging**<br><br>**Credit Hours: 2**<br><br>**Prerequisites**: GS02 1223: Diagnostic Medical Imaging II<br><br>Meeting Location: **UT MDACC Main Building (Physics Classroom)**<br><br>Building/Room#: **FCT 14.5059** | **Program Required Course: No**<br><br>**Approval Code: Yes**<br>**(If yes,** the Course Director or the Course Designee will provide the approval code.)<br><br>Audit Permitted: **Yes**<br><br>Classes Begin: **January 12, 2026**<br><br>Classes End: **May 8, 2026**<br><br>Final Exam Week: **N/A** |

**Class Meeting Schedule**

| Day | Time |
|---|---|
| **Tuesday/Thursday** | **9:30—10:30 a.m.** |

**Course Director**

Name and Degree: **Chris Walker, PhD**

Title: Assistant Professor

Department: Imaging Physics

Institution: MDACC

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**Course Co-Director:**

Name and Degree: **R. Jason Stafford, PhD**

Title: Professor

**Instructors**

1. **Chris Walker, PhD**
   Institution: MDACC
   Email Address: CMwalker@mdanderson.org
2. **R. Jason Stafford, PhD**
   Institution: MDACC
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3. **James Bankson, PhD**
   Institution: MDACC

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**NOTE:** Office hours are available by request. Please email me to arrange a time to meet.

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4. **Ken Hwang, PhD**

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6. **Brian Taylor, PhD**

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**Course Description**: This course provides an in-depth exploration of Magnetic Resonance Imaging (MRI) principles, techniques, and applications. Beginning with the classical descriptions of nuclear spins, students will develop a foundation in spin dynamics, relaxation mechanisms, and the Bloch equations. The course then transitions to practical aspects of MRI, including RF pulse design, gradient systems, k-space theory, and image reconstruction methods. Emphasis is placed on understanding how hardware, acquisition strategies, and signal processing influence image quality, contrast, and artifacts.

Advanced topics include non-Cartesian sampling, parallel imaging, compressed sensing, and specialized imaging techniques such as diffusion, perfusion, spectroscopy, and functional MRI. Students will also examine safety considerations, protocol optimization for various anatomical regions, and emerging trends in MR technology. Hands-on exercises using the open source PulSeq pulse programing platform will reinforce theoretical concepts through practical implementation. By the end of the course, students will be equipped to critically analyze MRI systems and design optimized imaging protocols for research and clinical applications.

**Textbook/Supplemental Reading Materials**

- **Bernstein, M. A., King, K. F., & Zhou, X. J. *Handbook of MRI Pulse Sequences*. Academic Press.**
- **Haacke, E. M., Brown, R. W., Thompson, M. R., & Venkatesan, R. *Magnetic Resonance Imaging: Physical Principles and Sequence Design*. Wiley.**

**Course Objective/s:**

Upon successful completion of this course, students will achieve a comprehensive understanding of MRI physics, hardware, and advanced imaging techniques. Students will learn to apply theoretical principles to practical imaging challenges, including protocol design and artifact mitigation. By integrating hands-on reconstruction exercises, the course aims to prepare students for research and clinical roles in MRI technology development and application.

***Specific Learning Objectives*:**

1. Describe and analyze the principles of MRI signal generation and spatial encoding, including the role of RF pulses, gradient fields, and hardware components in image formation.

2. Compare and implement common pulse sequences (gradient echo and spin echo) and explain their impact on image contrast, acquisition time, and artifact susceptibility.

3. Evaluate sampling and reconstruction strategies, including Cartesian and non-Cartesian approaches, and apply advanced techniques such as parallel imaging (SENSE, GRAPPA), compressed sensing, and AI-based reconstruction.

4. Assess and optimize imaging protocols for specific clinical applications, including CNS, MSK, cardiac, and body imaging, while considering alternative contrast mechanisms (spectroscopy, diffusion, perfusion, angiography).

5. Apply MR safety principles and troubleshoot artifacts, ensuring compliance with safety standards for both environmental and implanted device scenarios, and demonstrate competency in quality assurance practices.

**Student responsibilities and expectations:**

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

1. Read, process, and review the relevant textbook chapters
2. Attend and actively engage in both lectures
3. Prepare for and take course quizzes based on course lectures/ readings.
4. Prepare code for the weeks lab
5. Participate in and contribute to course discussions during the weekly lab

Students are expected to complete all assigned reading material (reviews and research literature) prior to class. Students must adhere to academic integrity standards and submit all work on time. Regular attendance, collaboration in group activities, and proactive communication with the instructor are essential for successful completion of the course.

| Grading System: **Letter Grade** | |
|---|---|
| **Student Assessment and Grading Criteria** : *(May include the following:)* | |
| **Percentage** | **Description** |
| Participation and/or Attendance ( 40 %) | Take home quizzes will be given after certain lecture modules. |
| Workshop or Breakout-Session ( 35 %) | There will be many labs which will be completed and graded. |
| Participation and/or Attendance ( 25 %) | |

**CLASS SCHEDULE**

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| **1/13/2026** | 1 | Introduction | Walker |
| **1/20/2026** | 1 | Spatial Encoding | Stafford |
| **1/22/2026** | 1 | MRI Signal Generation | Walker |
| **1/23/2026** | Lab | Introduction to PulSeq | Walker |
| **1/27/2026** | 1 | RF Pulses I: Simple Pulses | Hwang |
| **1/29/2026** | 1 | Gradient Pulses | Stafford |
| **1/30/2026** | Lab | Excitation and Slice Select | Walker |
| **2/3/2026** | 1 | MRI Hardware I:, Super Conductor, Shim, Gradients | Bankson |
| **2/5/2026** | 1 | RF Pulses II: Advanced pulses | Hwang |
| **2/6/2026** | Lab | Spin Echo, T1 and T2 Measurement | Walker |
| **2/10/2026** | 1 | Gradient Echo Based Pulse Sequences I | Taylor |
| **2/12/2026** | 1 | MRI Hardware II: RF, Excitation, Reception, Shielding | Bankson |
| **2/13/2026** | Lab | Gradient Echo, T2* measurement, | Walker |
| **2/17/2026** | 1 | Spin Echo Based Pulse Sequences I | Ma |
| **2/19/2026** | 1 | Gradient Echo Based Pulse Sequences II | Taylor |
| **2/20/2026** | Lab | Frequency Encode, Geometric accuracy | Walker |
| **2/24/2026** | 1 | Sampling & Reconstruction I: 2D/3D Cartesian Sampling & Artifacts | Stafford |
| **2/26/2026** | 1 | Spin Echo Based Pulse Sequences II | Ma |
| **2/27/2026** | Lab | Phase Encode | Walker |
| **3/3/2026** | 1 | Sampling & Reconstruction III – SENSE GRAPPA | Hwang |
| **3/5/2026** | 1 | Sampling & Reconstruction II: Non-Cartesian Sampling & Artifacts | Stafford |

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| **3/6/2026** | Lab | First gradient Echo Image | Walker |
| **3/12/2026** | 1 | Sampling & Reconstruction III: CAIPI, Compressed Sensing, SMS, AI recon | Hwang |
| **3/13/2026** | Lab | First Spin Echo Sequence | Walker |
| **3/17/2026** | 1 | Signal, noise statistics and signal-to-noise ratio | Walker |
| **3/20/2026** | Lab | Spring Break | Walker |
| **3/24/2026** | 1 | Alternative Contrast I: Spectroscopy & Spectroscopic Imaging | Taylor |
| **3/26/2026** | 1 | Spin Preparation & Chemical Species Selection/Suppression | Walker |
| **3/27/2026** | Lab | FSE and EPI | Walker |
| **3/31/2026** | 1 | Alternative Contrast III: Parametric Mapping | Taylor |
| **4/2/2026** | 1 | Alternative Contrast II: Diffusion, Perfusion, Bold | Liu |
| **4/3/2026** | Lab | 3D Imaging | Taylor |
| **4/7/2026** | 1 | Protocol Focus I: CNS (Brain) | Liu |
| **4/9/2026** | 1 | Alternative Contrast III: Flow, Angiography | Stafford |
| **4/10/2026** | Lab | Parallel Imaging 1 SENSE | Walker |
| **4/14/2026** | 1 | Protocol Focus III: MSK/Spine | Hwang |
| **4/16/2026** | 1 | Protocol Focus II: Body (Abdomen/Pelvis) Motion focus | Walker |
| **4/17/2026** | Lab | Parallel Imaging 2 GRAPPA | Walker |
| **4/21/2026** | 1 | Hyperpolarized MR | Bankson |
| **4/23/2026** | 1 | Protocol Focus IV: Specialty (Cardiac/Breast) | Taylor |
| **4/24/2026** | Lab | Spin Preparation, Fat Sat | Walker |
| **4/28/2026** | 1 | MR Safety for Physicists I: Environment | Stafford |
| **4/30/2026** | 1 | Artifacts, Troubleshooting & QA | Walker |
| **5/1/2026** | Lab | Multi-Nuclear Imaging, Pre-scan | Walker |
| **5/7/2026** | 1 | MR Safety for Physicists II: Implanted Devices | Stafford |
| **5/8/2026** | Lab | Quantitative Imaging with phantoms | Taylor |

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