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 Coordinators, Cheryl Spitzenberger or Natalie Sirisaengtaksin. 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: **Spring 2023** Course Number and Course Title: **GS02 1103: Intro to Medical Physics II: Medical Imaging** Credit Hours: **3** Meeting Location: **MDA Faculty Center** Building/Room#**: FCT14.5059** WebEx/Zoom Link: **Will provide when classes start**	**Program Required Course: Yes** **Approval Code: Yes** **(If yes,** the Course Director or the Course Designee will provide the approval code.) **Audit Permitted: No** Classes Begin: **January 9, 2023** Classes End: **April 28, 2023** Final Exam Week: **May 3, 2023**

Class Meeting Schedule

Day	Time
M-W-F	**11:00 am – 12:00 noon**

Course Director Name and Degree: **Xiujiang John Rong, PhD** Title: **Professor** Department: **Imaging Physics** Institution: *MDACC* Email Address: Joh.Rong.@mdanderson.org Contact Number: 713-745-1365 **Course Co-Director/s:** Name and Degree: **N/A** Title: Department: Institution: *UTH* *MDACC* Email Address: Contact Number:	**Instructor/s** 1. **Moiz Ahmad, PhD** Institution: MDACC Email Address: MAhmad@mdanderson.org 2. **Frank Dong, PhD** Institution: MDACC Email Address: FDong1@mdanderson.org 3. **William Geiser, MS** Institution: MDACC Email Address: WGeiser@mdanderson.org 4. **Xinming Liu, PhD** Institution: MDACC Email Address: XLiu@mdanderson.org

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

Teaching Assistant: (if any)

N/A
Name and Email Address

5. **John Rong, PhD**
   Institution: MDACC
   Email Address: John.Rong@mdanderson.org

6. **Janet Ching-Mei Feng, PhD**
   Institution: UT Health/UT Medical School
   Email Address: Ching.Mei.Feng@uth.tmc.edu

7. **Megan Jacobsen, PhD**
   Institution: MDACC
   Email Address: MCJacobsen@mdanderson.org

Course Description:

This course includes the production of x-rays, conventional x-ray radiography, fluoroscopy, mammography as well as digital x-ray imaging modalities, computed tomography, and picture archiving and communication systems (PACS). It covers the basic principles of medical imaging physics, the fundamental characteristics of each imaging modality, the major components of medical imaging systems, the principles of image formation and reconstruction, the attributes used to assess the performance and image quality of an imaging system, and radiation dosimetry in diagnostic imaging.

Textbooks

- **The Essential Physics of Medical Imaging, 4th edition, Bushberg, et al, Wolters Kluwer, 2021.**
- **ISBN: 978-1975-1-0322-4, $199.99**

Course Objective/s:
Upon successful completion of this course, students will understand the basic principles of medical x-ray imaging physics, imaging technologies, systems, and acquire hands-on experiences including radiography, mammography, and computed tomography.

***Specific Learning Objectives*:**

1. Understand the basic principles of medical imaging physics and describe the fundamental characteristics of each imaging modality.
2. Identify the major components of medical imaging systems, describe the basic design of imaging technology, and explain the principles of image formation and reconstruction.
3. Identify and describe the attributes used to assess the performance/image quality of an imaging

system.

4. Understand how image quality and patient radiation dose are affected by x-ray interactions.

5. List the image acquisition parameters, and explain how each affects the image quality and/or patient radiation dose.

Student Responsibilities and Expectations:
Students enrolled in this course will be expected to perform the following activities:

1. Attend classroom lectures
2. Participate in hands-on labs
3. Participate in and contribute to course discussions during lecture, review sessions, and hands-on labs
4. Study course materials (e.g. textbook, lecture slides, lab instructions, literatures)
5. Complete course assignments (e.g. homeworks, projects, lab reports) on time
6. Prepare for and take examinations

Students are expected to complete all assigned reading material (e.g. textbook chapters, lab instructions) prior to class/lab. While you may work and discuss all course materials and assignments in groups, all writing assignments must be your own. Plagiarism and failure to properly cite scientific literature and other sources will not be tolerated and are grounds for dismissal from the course and further GSBS disciplinary action. Cheating or engaging in unethical behavior during examinations 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 (15-18%)	Assigned by the individual instructor as needed
Quiz (1-3%)	Assigned by the individual instructor as needed
Presentation (0%)	Assigned by the individual instructor as needed
Midterm Exams (~60%)	3 exams total, no final exam
Final Exam (%)	NA

Workshop or Lab (~20-25%)	5 Hands-on labs
Participation and/or Attendance (0%)	Students are required to attend the entire class.

JR/jal

GS02-1103: INTRODUCTION TO MEDICAL PHYSICS II: MEDICAL IMAGING

SPRING 2023 SCHEDULES

Day: MWF, January 9 – April 28, 2022; Final exam on May 3, 2023
Time: 11:00 am – 12:00 Noon

Room: FCT14.5059 Physics Classroom and virtual classroom lectures via Zoom

Contact: **John Rong, PhD**, course coordinator
FCT14.5020, 713-745-1365, john.rong@mdanderson.org
Admin Assistant: **Margaret Copeland**
FCT14.6072, 713-792-8093, MRCopeland@mdanderson.org

Instructors: Moiz Ahmad, Ph.D.
Frank Dong, Ph.D.
Janet Ching-Mei Feng, Ph.D. (UT Health/UT Medical School)
William Geiser, M.S.
Megan Jacobsen, Ph.D.
Xinming Liu, Ph.D.
John Rong, Ph.D. (Coordinator)

Grading (including homework, projects, labs, quizzes and exams):

X-ray A:	33%
X-ray B:	33%
CT:	34%

Textbooks and other materials:

Required:

1. *The Essential Physics of Medical Imaging*, 4th edition, Bushberg, et al, Wolters Kluwer, 2021. ISBN: 978-1975-1-0322-4, $199.99.

Recommended:

1. *Physics of Radiology*, 2nd edition, Anthony Wolbarst, Medical Physics Publishing Corp., 2005. ISBN: 1930524226.
2. *Medical Imaging Physics*, 4th edition, William R. Hendee and E. Russell Ritenour, John Wiley & Sons, 2002. ISBN: 0471382264.
3. *Imaging Systems for Medical Diagnostics: Fundamentals, Technical Solutions and Applications for Systems Applying Ionizing Radiation, Nuclear Magnetic Resonance and Ultrasound*, Arnulf Oppelt (Editor), Wiley-VCH, 2006. ISBN: 3895782262.
4. *Computed Tomography: Principles, Design, Artifacts, and Recent Advances*, Jiang Hsieh, SPIE Press, 2003. ISBN: 0819444251.
5. *Computed Tomography: Fundamentals, System Technology, Image Quality, Applications*, 2nd edition, Willi A. Kalender, Wiley-VCH, 2006. ISBN: 3895782165.
6. *Medical CT and Ultrasound: Current technology and Applications*, Lee W. Goldman and J.Brian Fowlkes, Proceedings of the 1995 AAPM Summer School, Advanced Medical Publishing, Inc. 1995. ISBN: 1883526035.

7. *The Expanding Role of medical Physics in Diagnostic Imaging*, G. Donald Frey and Perry Sprawls, Proceedings of the 1997 AAPM Summer School, Advanced Medical Publishing, Inc. 1997. ISBN: 1888340096.
8. *Practical Digital imaging and PACS*, J. Anthony Seibert, et al, AAPM Medical Physics Monograph No. 25, Medical Physics Publishing Corp, 1999. ISBN: 0944838200.
9. *Intravascular Brachytherapy and Fluoroscopically Guided Interventions*, Stephen Balter, et al, AAPM Medical Physics Monograph No. 28, Medical Physics Publishing Corp, 2002. ISBN: 1930524102.
10. *Specifications, Performance Evaluations, and Quality Assurance of radiographic and Fluoroscopic Systems in the Digital Era*, Lee W. Goldman and Michael V. Yester, AAPM Medical Physics Monograph No. 30, Medical Physics Publishing Corp, 2004. ISBN: 1930524218.
11. *Review of Radiologic Physics*, 3rd edition, Walter Huda, Lippincott Williams & Wilkins, 2009. ISBN: 0781785693. ISBN-13: 978-0781785693.
12. RAPHEX Examinations on Diagnostic Radiologic Physics, published for RAMPS by Medical Physics Publishing Corp.

Web based teaching modules:

1. RSNA/AAPM Online Physics Modules at http://www.aapm.org/education/webbasedmodules.asp
2. IAEA RPOP training materials at http://rpop.iaea.org/RPOP/RPoP/Content/AdditionalResources/Training/1_TrainingMaterial/Radiology.htm
3. Dr. Perry Sprawls' Physical Principles of Medical Imaging Online at http://www.sprawls.org/resources/
4. ImPACT: Imaging Performance Assessment of CT Scanners at http://www.impactscan.org/

Lecture schedule (updated on 03/15/2023):

Date	Lecture	Title	Instructor
		INTRODUCTION	
1/9	1	Course overview, introduction to diagnostic imaging modalities and image physics practices	Rong
		X-RAY A	
1/11	2	X-ray Production: x-ray tube construction, anode, cathode, focal spot, x-ray filtration	Dong
1/13	3	X-ray Production: x-ray generator, major components, AEC	Dong
1/16		**Martin Luther King Holiday (no class)**	
1/18	4	X-ray Interactions, attenuation coefficients, beam quality	Dong
1/20	5	Radiography: image formation, H&D, focal spot blurring	Liu
1/23	6	Radiography: latitude, contrast, dose, scatter, image noise	Liu
1/25	7	Historical development and physics principles of mammography systems, modes of operations	Geiser
1/27	8	Mean glandular dose, ACR QC tests	Geiser
1/30	9	Digital Radiography/Mammography: digital detectors, CCD, CR, FP	Liu
2/1	10	Digital Radiography/Mammography: digital image correction, image processing and enhancement	Liu

2/3	Lab 2	**No lecture today. The lab instructor may discuss the lab or coordinate with you for doing the lab at a different date/time.**	Geiser
2/6	Lab 1	**No lecture today. The lab instructor may discuss the lab or coordinate with you for doing the lab at a different date/time.**	Liu
2/8	11	Advances in Radiography: Dual Energy, Digital Tomosynthesis	Liu
2/10	12	Standards, Networks/Gateways, PACS, Displays	Liu
2/13	13	"Big Data", basic image processing, 3D visualization and printing, Radiomics and AI	Liu
2/15		"X-Ray A" review session	Dong, Geiser, Liu
		X-RAY B	
2/17	14	Fluoroscopic imaging chain and components, x-ray source assembly	Rong
2/20	15	Controls, modes of operation, image processing, image quality and radiation dose in fluoroscopic procedures	Rong
2/22	16	Image quality, patient radiation management, personnel radiation safety in fluoroscopy	Rong
2/24		**Exam 1: X-ray A (11:00am – 12:30pm)**	Liu
2/27	17	Image Quality I: Signal, Contrast, Effects of Scatter/Glare	Liu
3/1	18	Image Quality II: Spatial Resolution, PSF, MTF	Liu
3/3	19	Image Quality III: Noise Properties, SNR, CNR, Figure of merit	Liu
3/6	20	Image Quality IV: NPS, NEQ, DQE	Liu
3/8	21	Observer Performance – Perceptional Study, contrast-detail, ROC	Liu
3/10	22	Review radiation terms and units, dose metrics, radiation dose in x-ray imaging, Diagnostic Reference Levels and Achievable doses	Dong
3/13-17		**Spring Break (no classes)**	
3/20	23	Overview of radiation protection in diagnostic imaging	Feng (UTH)
3/22	24	Structural shielding in diagnostic imaging	Feng (UTH)
3/24		"X-Ray B" review session	Dong, Feng, Liu, Rong
		COMPUTED TOMOGRAPHY	
3/27	25	CT fundamentals and historical development, CT practices at MDA	Dong
3/29	26	CT system designs	Dong
3/31	27	CT imaging acquisition modes	Dong
4/3		**Exam 2: X-ray B (11:00am – 12:30pm)**	Liu
4/5	28	CT Reconstruction: projection and sinogram, filtered backprojection, reconstruction algorithms	Ahmad
4/7	29	CT Reconstruction: concept of cone beam, iterative, and Deep Learning based reconstructions, available clinical options	Ahmad
4/10	30	CT Image Quality: spatial resolution, low-contrast detectability, noise/CNR, factors affecting CT image quality, tools/phantoms for image quality evaluation	Dong
4/12	31	CT Image Quality: causes of image artifacts and possible solutions for artifact reduction	Dong
4/14	Lab 4	**No lecture today. The lab instructor may discuss the lab or coordinate with you for doing the lab at a different date/time.**	Dong
4/17	32	CT Radiation Dosimetry: MSAD, CTDI, DLP, dose report, SSDE	Ahmad

4/19	Lab 5	**No lecture today. The lab instructor may discuss the lab or coordinate with you for doing the lab at a different date/time.**	Ahmad
4/21	33	Overview of CT accreditation programs, ACR requirements, physicist responsibility, phantom testing and dosimetry	Rong
4/24	34	DECT and photon counting CT	Ahmad
4/26	35	Clinical CT applications	Ahmad
4/28		CT review session	Ahmad, Dong, Rong
5/3		**Exam 3: CT (11:00am – 12:30pm)**	

Lab schedule (updated on 03/01/2023):

Date	Location	Lab	Title	Instructor
2/7	BSRT Lab	1	Image formation, image quality and dosimetry in radiographic imaging	Liu
2/22	ACB5	2	Image formation, image quality and annual performance testing in mammographic imaging	Geiser/Jacobsen
NA	TBD	3	CT Imaging simulation and reconstruction	Ahmad
NA	BSRT Lab	4	CT image quality	Dong
NA	BSRT Lab	5	CTDI measurements and patient dose estimate	Ahmad