BME 4531 – MEDICAL IMAGING – SPRING 2023

Instructor:
Wesley Bolch, PhD, (352) 273-0303, wbolch@ufl.edu
Office Hours: By appointment
Email Correspondence: If emailing about class issues, please use the email facility within Canvas.

Teaching Assistant:
Yitian Wang, Biomedical Engineering PhD Student, yitian.wang@ufl.edu
Office Hours: By appointment
Email Correspondence: If emailing about class issues, please use the email facility within Canvas.

Course Description (3 Credits)
This course covers medical imaging from a biomedical engineering perspective. Topics include the fundamental physics, mathematics, instrumentation, and clinical applications of imaging modalities to include: x-ray radiography, fluoroscopy, computed tomography, ultrasound, magnetic resonance imaging, and nuclear medicine imaging.

Course Pre-Requisites / Co-Requisites: MAC 2313, MAP 2302, and PHY 2049 with minimum grades of C

Course Objectives:
Learn the principles of operation of medical imaging modalities used clinically – including x-ray imaging, CT, ultrasound, magnetic resonance imaging, and nuclear medicine; Develop understanding of analytical methods and theory that have general application across medical imaging modalities; Develop competence in analytical software tools useful in medical imaging.

Meeting Times: Tuesday, Period 4, 10:40 am – 11:30 am, Anderson Hall Room 0134
Thursday, Period 4-5, 10:40 am – 12:35 pm, Anderson Hall Room 0134
Meeting Location: All lectures will be delivered face-to-face in Anderson Hall Room 0134

Required Textbook:
The Essential Physics of Medical Imaging
Jerrold T. Bushberg, 4th Edition
Wolters Kluwer (2020)

Required Software
MATLAB (mathworks.com)
ImageJ (imagej.nih.gov)

Attendance and Expectations:
Students are expected to attend all classes in person. Students must notify the instructor of expected absence in advance, and make arrangements to make up missed material. Excused absences must be consistent with university policies in the undergraduate catalog (https://catalog.ufl.edu/UGRD/academic-regulations/attendance-policies/) and require appropriate documentation. Attendance will be monitored through periodic verification in class. During class, all students must put away all cell phones. Students are encouraged to bring laptops to class for class note taking. Professionalism standards will be enforced on reviewer papers and are subject to plagiarism checks.

Grading Policy	Total Points	% of Final Grade	Evening Exams / Due Dates
Homework Assignments (6)	100 each	20%	
Discussion Assignments (6)	100 each	10%	
Attendance and Quizzes	30 each	10%	
Exam 1 – in class	100	15%	**Tuesday – February 6**
Exam 2 – in class	100	15%	**Tuesday – March 11**
Exam 3 – 5:30 to 8:30 pm	100	15%	**Thursday – May 4**
Review Papers - Submitted	85	15%	**Sunday – April 16**
Review Papers - Returned			**Sunday – April 23**
Review Papers - Resubmitted	15		**Sunday – April 30**

Lecture Schedule

Week	Date		Lecture No. and Topic	Chapters	Lecturer
1	**Jan**	10	**M1** - Course Introduction / Review of Imaging Modalities	Chapter 1	Bolch
		12	**M2** - Review of Photon Interactions	Chapter 3	Bolch
		12	**M2** - Review of Photon Interactions	Chapter 3	Bolch
2		17	**M3** – Review of Electron Interactions	Chapter 3	Bolch
		19	**M4** - X-Ray Production and Generators	Chapter 6	Bolch
		19	**M5** - Radiography	Chapter 7	Bolch
3		23	**M5** – Radiography (continued)	Chapter 7	Bolch
		26	**M6** - Mammography and Digital Tomosynthesis	Chapter 8	Bolch
		26	**M6** - Mammography and Digital Tomosynthesis	Chapter 8	Bolch
4		31	**UF Library Resources – Literature Review and Citations**		**Amy Buhler**
	Feb	2	**M7** - Fluoroscopy – Diagnostic	Chapter 9	Bolch
		2	**M8** - Fluoroscopy – Interventional	Chapter 9	Bolch
5		7	**A1** – Medical Imaging Informatics	Chapters 4-5	Bolch / Wang
		9	**M9** - Computed Tomography	Chapter 10	Bolch
		9	**M9** - Computed Tomography	Chapter 10	Bolch
6		14	**Exam 1 – In Class**		
		16	**M10** - X-ray Dosimetry in Projection Imaging and CT	Chapter 11	Bolch
		16	**M10** - X-ray Dosimetry in Projection Imaging and CT	Chapter 11	Bolch
7		21	**A2** – Image Display / **A3** – Image Processing	Chapters 4-5	Bolch / Wang
		23	**M11** - Magnetic Resonance Basics	Chapter 12	Bolch
		23	**M11** - Magnetic Resonance Basics	Chapter 12	Bolch
8		28	**A4** – Frequency Domain and Image Convolution	Chapters 4-5	Bolch / Wang
	Mar	2	**M12** - Magnetic Resonance Imaging	Chapter 13	Bolch
		2	**M12** - Magnetic Resonance Imaging	Chapter 13	Bolch
9		7	**A5** – Spatial Resolution / **A6** – Contrast Resolution	Chapters 4-5	Bolch / Wang
		9	**M13** - Ultrasound Imaging	Chapter 14	Bolch
		9	**M13** - Ultrasound Imaging	Chapter 14	Bolch
10		14	***No Classes – Spring Break***		
		16	***No Classes – Spring Break***		
		16	***No Classes – Spring Break***		
11		21	**A7 –** Detective Quantum Efficiency and ROC Curves	Chapters 4-5	Bolch / Wang
		23	**Review Paper Proposal Review / Presentations**		
		23	**Review Paper Proposal Review / Presentations**		
12		28	**Exam 2 – In Class**		
		30	**M14** - Radioactivity and Nuclear Transformations	Chapter 15	Bolch
		30	**M15** - Radionuclide Production and Radiopharmaceuticals	Chapter 16	Bolch
13	**Apr**	4	**A8** – Image Artifacts / **A9** – Quality Control	Chapters 4-5	Bolch / Wang
		6	**M16** - Radiation Detection and Measurement	Chapter 17	Bolch
		6	**M16** - Radiation Detection and Measurement	Chapter 17	Bolch
14		11	**A10** – Field of Biomedical Imaging / Preclinical Applications		Bolch
		13	**M17** - Nuclear Imaging – The Scintillation Camera	Chapter 18	Bolch
		13	**M17** - Nuclear Imaging – The Scintillation Camera	Chapter 18	Bolch
15		18	**A11** – Use of Medical Imaging in the Radiotherapy of Cancer		
		20	**M18** - Nuclear Imaging – Emission Tomography	Chapter 19	Bolch
		20	**M18** - Nuclear Imaging – Emission Tomography	Chapter 19	Bolch

16		25	**M19** - Radiopharmaceutical Cancer Therapy	Notes	Bolch
	May	4	**Exam 3 (Thursday, May 4, 5:30 to 7:30 pm)**		

Exams: Three exams will be given during the semester. These exams will be given as time-limited closed book exams – matching, short answer, and multiple choice. Make-up exams will only be considered for exceptional circumstances and will be implemented by the instructor on a case-by-case basis. Notice of the absence must be given to the instructor prior to each exam.

Review Papers: Student groups (4 students) are asked to select a topic related to a given set of imaging modalities and specific clinical imaging applications, and perform a detailed literature review of that topic. The review article will follow the *Instructions to Contributors* for the journal *Physics in Medicine and Biology*. A list of suggested topics will be discussed in class. Grades for the final manuscripts will be based upon (1) technical content, (2) writing style, and (3) adherence to journal article submission guidelines.

Students are asked to follow the author instructions, except for the following:

- Limit your total number of pages of text (Abstract to Conclusions) to no more than 15 pages and no fewer than 10 pages.
- Submit both a Cover Letter and a Manuscript (with embedded tables and figures) all in MS Word format
- Use the following file names:
  - Cover Letter – Group#.docx,
  - Paper – Group#.docx.
- Each paper must have at least two tables and two figures.
- Each paper must have cited a minimum of 10 peer-reviewed journal article citations (beyond textbooks or conference proceedings) and should have no more than 3 website citations.

Each manuscript will be submitted with a cover letter to the appropriate Editor-in-Chief noting why you think your work is worthy of publication. Final manuscripts are due by email on Sunday, **April 16**. Reviewed manuscripts will be returned by Sunday, **April 23**. A resubmitted manuscript with a revised Cover Letter and Response to Comments will be due by Sunday, **April 30**. **All papers will be subject to plagiarism review using Turnitin.**

Grading Policy

Percent	Grade	Grade Points
93.4 - 100	A	4.00
90.0 - 93.3	A-	3.67
86.7 - 89.9	B+	3.33
83.4 - 86.6	B	3.00
80.0 - 83.3	B-	2.67
76.7 - 79.9	C+	2.33
73.4 - 76.6	C	2.00
70.0 - 73.3	C-	1.67
66.7 - 69.9	D+	1.33
63.4 - 66.6	D	1.00
60.0 - 63.3	D-	0.67
0 - 59.9	E	0.00

More information on UF grading policy may be found at:
https://catalog.ufl.edu/ugrad/current/regulations/info/grades.aspx

Relation to ABET Program Outcomes

Outcome	Coverage*
1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.	High - Emphasized
2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare as well as global, cultural, social environmental, and economic factors.	
3. An ability to communicate effectively with a range of audiences	
4. An ability to recognize ethical and professional responsibilities in engineering situations and make informal judgements, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.	Low - Reinforced
5. An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meeting objectives.	
6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgement to draw conclusions.	
7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.	Low – Reinforced

* Coverage is given as high, medium, or low. An empty box indicates that this outcome is not part of the course.

Students Requiring Accommodations

Students with disabilities who experience learning barriers and would like to request academic accommodations should connect with the disability Resource Center by visiting https://disability.ufl.edu/students/get-started/. It is important for students to share their accommodation letter with their instructor and discuss their access needs, as early as possible in the semester.

Course Evaluation

Students are expected to provide professional and respectful feedback on the quality of instruction in this course by completing course evaluations online via GatorEvals. Guidance on how to give feedback in a professional and respectful manner is available at https://gatorevals.aa.ufl.edu/students/. Students will be notified when the evaluation period opens, and can complete evaluations through the email they receive from GatorEvals, in their Canvas course menu under GatorEvals, or via https://ufl.bluera.com/ufl/. Summaries of course evaluation results are available to students at https://gatorevals.aa.ufl.edu/public-results/.

Online Course Recording

Our class sessions may be audio visually recorded for students in the class to refer back and for enrolled students who are unable to attend live. Students who participate with their camera engaged or utilize a profile image are agreeing to have their video or image recorded. If you are unwilling to consent to have your profile or video image recorded, be sure to keep your camera off and do not use a profile image. Likewise, students who un-mute during class and participate orally are agreeing to have their voices recorded. If you are not willing to consent to have your voice recorded during class, you will need to keep your mute button activated and communicate exclusively using the "chat" feature, which allows students to type questions and comments live. The chat will not be recorded or shared. As in all courses, unauthorized recording and unauthorized sharing of recorded materials is prohibited.

In-Class Recording

Students are allowed to record video or audio of class lectures. However, the purposes for which these recordings may be used are strictly controlled. The only allowable purposes are (1) for personal educational use, (2) in connection with a complaint to the university, or (3) as evidence in, or in preparation for, a criminal or civil proceeding. All other purposes are prohibited. Specifically, students may not publish recorded lectures without the written consent of the instructor.

A "class lecture" is an educational presentation intended to inform or teach enrolled students about a particular subject, including any instructor-led discussions that form part of the presentation, and delivered by any instructor hired or appointed by the University, or by a guest instructor, as part of a University of Florida course. A class lecture does not include lab sessions, student presentations, clinical presentations such as patient history, academic exercises involving solely student participation, assessments (quizzes, tests, exams), field trips, private conversations between students in the class or between a student and the faculty or lecturer during a class session.

Publication without permission of the instructor is prohibited. To "publish" means to share, transmit, circulate, distribute, or provide access to a recording, regardless of format or medium, to another person (or persons), including but not limited to another student within the same class section. Additionally, a recording, or transcript of a recording, is considered published if it is posted on or uploaded to, in whole or in part, any media platform, including but not limited to social media, book, magazine, newspaper, leaflet, or third-party note/tutoring services. A student who publishes a recording without written consent may be subject to a civil cause of action instituted by a person injured by the publication and/or discipline under UF Regulation 4.040 Student Honor Code and Student Conduct Code.

University Honesty Policy

UF students are bound by The Honor Pledge which states, "We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: "On my honor, I have neither given nor received unauthorized aid in doing this assignment." The Conduct Code (https://sccr.dso.ufl.edu/process/student-conduct-code/) specifies a number of behaviors that are in violation of this code and the possible sanctions. If you have any questions or concerns, please consult with the instructor or TAs in this class.

Commitment to a Safe and Inclusive Learning Environment

The Herbert Wertheim College of Engineering values broad diversity within our community and is committed to individual and group empowerment, inclusion, and the elimination of discrimination. It is expected that every person in this class will treat one another with dignity and respect regardless of gender, sexuality, disability, age, socioeconomic status, ethnicity, race, and culture.

If you feel like your performance in class is being impacted by discrimination or harassment of any kind, please contact your instructor or any of the following:

- Your academic advisor or Graduate Program Coordinator
- Jennifer Nappo, Director of Human Resources, 352-392-0903, jpennacc@eng.ufl.edu
- Curtis Taylor, Associate Dean of Student Affairs, 352-392-2177, taylor@eng.ufl.edu
- Toshikazu Nishida, Associate Dean of Academic Affairs, 352-392-0943, nishida@eng.ufl.edu

Software Use

All faculty, staff, and students of the University are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against University policies and rules, disciplinary action will be taken as appropriate. We, the members of the University of Florida community, pledge to uphold ourselves and our peers to the highest standards of honesty and integrity.

Student Privacy

There are federal laws protecting your privacy with regards to grades earned in courses and on individual assignments. For more information, please see: https://registrar.ufl.edu/ferpa.html

Campus Resources - Health and Wellness

U Matter, We Care:
Your well-being is important to the University of Florida. The U Matter, We Care initiative is committed to creating a culture of care on our campus by encouraging members of our community to look out for one another and to reach out for help if a member of our community is in need. If you or a friend is in distress, please contact umatter@ufl.edu so that the U Matter, We Care Team can reach out to the student in distress. A nighttime and weekend crisis counselor is available by phone at 352-392-1575. The U Matter, We Care Team can help connect students to the many other helping resources available including, but not limited to, Victim Advocates, Housing staff, and the Counseling and Wellness Center. Please remember that asking for help is a sign of strength. In case of emergency, call 9-1-1.

Counseling and Wellness Center: http://www.counseling.ufl.edu/cwc, and 392-1575; and the University Police Department: 392-1111 or 9-1-1 for emergencies.

Sexual Discrimination, Harassment, Assault, or Violence
If you or a friend has been subjected to sexual discrimination, sexual harassment, sexual assault, or violence contact the **Office of Title IX Compliance**, located at Yon Hall Room 427, 1908 Stadium Road, (352) 273-1094, title-ix@ufl.edu

Sexual Assault Recovery Services (SARS)
Student Health Care Center, 392-1161.

University Police Department at 392-1111 (or 9-1-1 for emergencies), or http://www.police.ufl.edu/.

Campus Resources - Academic Resources

E-learning technical suppor*t*, 352-392-4357 (select option 2) or e-mail to Learning-support@ufl.edu. https://lss.at.ufl.edu/help.shtml.

Career Resource Center, Reitz Union, 392-1601. Career assistance and counseling. https://www.crc.ufl.edu/.

Library Support, http://cms.uflib.ufl.edu/ask. Various ways to receive assistance with respect to using the libraries or finding resources.

Teaching Center, Broward Hall, 392-2010 or 392-6420. General study skills and tutoring. https://teachingcenter.ufl.edu/.

Writing Studio, 302 Tigert Hall, 846-1138. Help brainstorming, formatting, and writing papers. https://writing.ufl.edu/writing-studio/.

Student Complaints Campus*:* https://sccr.dso.ufl.edu/policies/student-honor-code-student-conduct-code/ and https://care.dso.ufl.edu.

On-Line Students Complaints*:* http://www.distance.ufl.edu/student-complaint-process.