

BIOENGINEERING 4310/4311/6310/6311
SPRING 2016

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Office Hours: M 1:30p - 2:30p
Tu 10:30a - 11:30a
By Appointment

Lecture: Rhodes Annex 522
M W 2:30p - 3:20p

Lab: Rhodes Annex 316
F 11:15a - 1:15p

Prerequisites: (MATH 2080 - Introduction to Ordinary Differential Equations
and
ECE 2620 - Electronic Circuits II)
or
Concurrent Enrollment in BIOE 3700 - Bioinstrumentation and Bioimaging

1. OVERVIEW

Medical Imaging is all around us! Whether it is dental X-Rays, or intra-operative Ultrasound, imaging in one-way or another impacts us all. The application and development of medical imaging systems is an extremely multidisciplinary study, which includes methods in Anatomy and Physiology, Engineering, Physics, and Psychology just to name a few. In this course we will examine both the engineering of imaging systems, as well as the physics behind how they actually work. In addition to this, we will examine some of the clinical applications which medical imaging is used for and look at the tradeoffs between modalities. Throughout the course we will examine images as both a producer and consumer, with some focus given to image processing.

This course will focus on using a hands-on approach to imaging from the first day. Methods of simulation and analysis will be stressed, allowing students to experience the images rather than just read about them.

1.1. Critical Thinking (CT²). As part of Clemson University's accreditation with the Southeastern Association of Colleges and Schools Council on Colleges (SACS-COC) accreditation we have undertaken an initiative to promote critical thinking within our student population. This initiative helps improve Clemson University by providing our students with skills essential to real world problem solving and evaluation. By participating in this type of course you will learn new study skills while helping Clemson. *Be aware, the teaching methods, testing strategies, and overall interaction in this class may differ from other courses. Some methods may be experimental. BUT all CT² methods will be for the benefit of the student, and may change to improve the student experience.*

For more information on the CT² initiative please visit: <http://www.clemson.edu/assessment/thinks2>.

1.1.1. *The California Critical Thinking Test.* You will be asked to take an online test at the beginning and end of the course as a homework assignment called the California Critical Thinking Test, this test will assess your strengths in a number of areas of critical thinking. Your scores have no impact on your grade, your standing at Clemson, or anything else. Taking these exams helps Clemson University and myself improve teaching methods to improve the quality of our student progress. These exams typically take 45-50 minutes, and do not involve any studying, preparing, or outside work.

2. LEARNING OBJECTIVES

1. Differentiate and apply medical imaging modalities to patient scenarios based on the physical phenomena, on which the modalities are based
2. Describe the interactions of radiation with tissues and discuss the risks and benefits involved with medical imaging

3. Develop, design, and implement techniques for linear, non-linear, and statistical analysis of electronic images
4. Assess, evaluate, and justify the use and application of medical imaging techniques based on the underlying physical phenomena which these methods employ
 - (a) Explain, and model behavior of X-ray and CT Imaging based on basic physical principles
 - (b) Explain MRI using the simple "top" model of spins
 - (c) Understand the interactions of radiation with tissue, and compare and contrast images based on safety and risk/benefit
5. Explain the outputs of imaging modalities in terms of anatomy and physiology coupled with the physics which the modality employs
6. Design and justify a method for analyzing medical images based on basic image processing techniques

NOTE: Students may vary in their competency levels on these abilities. You can expect to acquire these abilities only if you honor all course policies, attend classes regularly, complete all assigned work in good faith and on time, and meet all other course expectations of you as a student.

3. GRADING

3.1. Undergraduate (BIOE 4310/4311).

Weekly Quizzes	40%
Final Exam	25%
Laboratory Exercises	35%

3.2. Graduate (BIOE 6310/6311).

Weekly Quizzes	30%
Final Exam	20%
Laboratory Exercises	30%
Term Project	20%

3.3. Grading Schema.

A	90 – 100%
B	80 – 89.9%
C	70 – 79.9%
D	60 – 69.9%
F	< 60%

4. COURSE MATERIALS

Textbooks.

Required.

- (1) Webb and N. Smith, **Introduction to Medical Imaging: Physics, Engineering, and Clinical Applications** (2011), Cambridge University Press, 1st ed., ISBN: 9780521190657 (hardback)

Recommended (For support with MATLAB).

- (1) A. Gilat, **MATLAB: an Introduction with Applications** (2011), J. Wiley & Sons, 4th ed., ISBN: 9780470767856 (paperback)
- (2) R. K. Johnson, **The Elements of MATLAB Style** (2011), Cambridge University Press, ed., ISBN: 9780521732581 (paperback) 0521732581 (paperback)

5. SOFTWARE

- (1) MATLAB™- Available FREE from CCIT
 - (a) You may use GNU Octave in place of MATLAB if you wish, it is equivalent to MATLAB and is available free on the web (<https://www.gnu.org/software/octave/>, Windows/Mac Installers: <http://octave.sourceforge.net>) *NB: We will not provide support for installation issues*
- (2) MeVisLab - Available FREE from <http://mevislab.de>

6. READINGS

Regular readings will be assigned from the textbook as well as from other journal articles, books, and websites. It is the student's responsibility to keep up on the material through readings and assignments. Please note readings specified later may be supplemented to improve student learning. Further students are encouraged to use other resources including but not limited to textbooks, journal articles, and web pages to supplement their learning.

7. REQUIREMENTS FOR GRADUATE CREDIT

To receive graduate credit in this course, students must complete a team based term project including analysis and processing of medical imaging data. Students will be asked to choose a project based on real world medical scenarios. The students will be encouraged to explore within their domain area, in order to bring diversity to the course material. Undergraduate students will be encouraged to help the graduate students with their efforts in order to enrich their experience.

8. GRADING DISPUTES

As all grading information is considered time critical, disputes on grades will only be permitted within one week of the return of graded material. Additionally, disputes must be made in writing along with the original copy of the graded material, and an explanation of the dispute. Disputes will be carefully considered and may result in either an increase or decrease in the grade on a given assignment.

9. DUE DATES AND ASSIGNMENTS

The use of simulations and models will be an important part of the learning experience in this course, and thus assignments will be an important component of this class's process. You will therefore be expected to complete all assignments on time and submit them. Some assignments will be able to be submitted electronically while others will need to be on paper. In the case of a paper assignment, it is due at the beginning of the classroom period in which the assignment is due. In the case of electronic submission, a specific deadline will be set per assignment. This deadline will be absolute, and no assignments will be accepted beyond this deadline.

Extenuating circumstances do occur and thus with prior approval assignments may be accepted late. Requests for approval must be submitted in writing a minimum of 24 hours before the nominal deadline of an assignment. You will be informed promptly as to the status of your request.

10. HONOR CODE AND ACADEMIC DISHONESTY

Academic dishonesty has no place in any academic environment, especially not at a great institution such as Clemson. Seeing as this, cheating or academic dishonesty will not be tolerated, and will be reported to seek disciplinary action per the College of Engineering and Science's Honor Code. A copy of this honor code can be found at:

<http://www.ces.clemson.edu/ge/Honor%20Code.htm>

You are encouraged to collaborate on assignments and projects; however, ultimately, you are responsible for submitting your own work. Make sure you cite all sources, including class members. It will acceptable to give a blanket citation for classmates with whom you worked.

If you have any questions as to how I define academic dishonesty, please contact the instructor.

Students violating the honor code or spirit of the honor code on any assignment, quiz, or exam will automatically fail the item. Incidents of academic dishonesty will be documented and referred to the appropriate department, college, and university administrators.

11. ACCOMMODATIONS FOR STUDENTS WITH DISABILITIES

Student Disability Services coordinates the provision of reasonable accommodations for students with physical, emotional, or learning disabilities. Accommodations are individualized, flexible, and confidential based on the nature of the disability and the academic environment in compliance with Section 504 of the Rehabilitation Act of 1973 and the Americans with Disabilities Act of 1990.

Students are encouraged to consult with the Disability Services staff early in the semester, preferably prior to the first day of class. Current documentation of a specific disability from a licensed professional is needed. Additional information or appointments are available from Student Disability Services, G-23 Redfern Health Center, 656-6848. Details on policies and procedures are available at <http://www.clemson.edu/asc>

12. EMERGENCY PROCEDURES

Emergency procedures have been posted in all buildings and on all elevators. Students should review these procedures for their own safety.

13. ATTENDANCE POLICY

This is a senior level class and will thus be moving at a relatively fast rate. Students are expected to attend class and are responsible for all material covered in the class as well as any material covered in the readings. Attendance to lecture and lab are expected and will provide you with information which may not be in any provided in any handouts. Missing class will hurt your overall grade and satisfaction with this course.

Attendance may be taken at any point during the semester. Students with more than 2 recorded absences will have their grades rounded down at the end of the semester, thus resulting in the loss of consideration for higher grades.

14. MISSED QUIZZES OR FINAL EXAM

While ideally students would be present at all quiz, lab periods, and the final exam it is understood that other obligations may make this not possible. Quizzes will be offered online for an extended period, and thus can be taken at the student's convenience. All students will have their lowest 2 quiz scores dropped, including those who miss a quiz. Students requiring more than 2 missed quizzes must discuss this with the instructor a minimum of 1 week before the third missed quiz for alternative accommodation. Students requiring accommodation for the final examination must alert the instructor immediately to arrange alternative accommodation, a minimum notification of 1 week before the end of classes is required.

If a lab period is missed, students must make arrangement for making-up the work with the instructor.

15. EXTRA CREDIT ASSIGNMENTS

The instructor reserves the right to provide additional assignments or projects for extra credit. In the unlikely event an extra credit assignment is offered, it will be available to all students at their request.

16. CURVING AND NORMALIZING

Grades may if necessary be curved and normalized at the end of the semester, this process will always be used to the benefit of the students. The letter grade divisions may be lowered, but will not be raised. This means a 90 will always be an A, an 80 will always be at least a B, and so on. If you have concerns about your grade please contact the instructor.

17. CLASSROOM DECORUM

You are expected to come to class on-time, and prepared for lecture. Students should not talk amongst themselves during lecture, as this distracts student's learning. Those disrupting teaching or other student's learning will be asked to leave and will be given an unexcused absence for the lecture. Students should not use their cellphones nor laptops during class unless they are specifically required for classwork. Students caught using phones or laptops for non-course related material will receive an automatic unexcused absence for the lecture.

18. TITLE IX

Clemson University is committed to a policy of equal opportunity for all persons and does not discriminate on the basis of race, color, religion, sex, sexual orientation, gender, pregnancy, national origin, age, disability, veteran's status, genetic information or protected activity (e.g., opposition to prohibited discrimination or participation in any complaint process, etc.) in employment, educational programs and activities, admissions and financial aid. This includes a prohibition against sexual harassment and sexual violence as mandated by Title IX of the Education Amendments of 1972. This policy is located at <http://www.clemson.edu/campus-life/campus-services/access/title-ix/>. Mr. Jerry Knighton is the Clemson University Title IX Coordinator. He also is the Director of Access and Equity. His office is located at 111 Holtzendorff Hall, 864.656.3181 (voice) or 864.565.0899 (TDD).

PLEASE NOTE: The schedule, policies, procedures, and assignments set out in this syllabus are subject to change in the case of extenuating circumstances, by mutual agreement, and/or to ensure better student learning.

SUMMARY OF TOPICS

Week	Topic	Reading
1	Introduction	
1-3	Review of Advanced Mathematics and MATLAB	Chapter 1.9
3-4	Imaging Basics	Chapter 1.1, 1.3-1.8
4-5	X-ray Imaging	Chapter 2.1 - 2.11
6	X-ray Computed Tomography	Chapter 1.9, 2.12-2.18
7-8	Nuclear Medicine	Chapter 3
9-11	Magnetic Resonance Imaging (MRI)	Chapter 5
12-13	Ultrasound	Chapter 4
14	Image Quality	Chapter 1.2
15	Practical Applications	