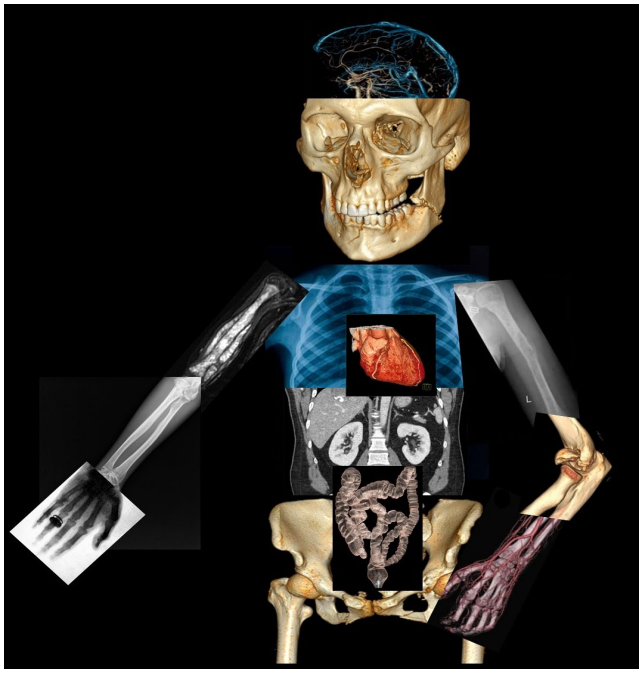
BME 426: Basics of Biomedical Imaging (Ionizing Radiation)

Fall – Units: 2.0

(2hr-sessions on Tuesdays and Thursdays) 7 weeks only

Finishes in early October!

Instructor: Prof. Cristina Zavaleta
Contact Info: czavalet@usc.edu



What you will learn during this class:

- What your insides really look like!
- How to impress your medical school instructors with your extensive knowledge of medical imaging principles and their clinical utility.
- How much ionizing radiation you receive after eating a banana vs. getting an x-ray.
- What the difference is between an X-Ray and a Gamma Ray.
- How to determine which imaging techniques are best suited to answer various clinical questions.
- How to show off to your friends and family about your medical imaging knowledge.

Course Description

Students will be introduced to various biomedical imaging methods that require the use of ionizing radiation sources. These include both clinical and preclinical imaging platforms: x-ray imaging including conventional radiography, mammography, fluoroscopy, computed tomography (CT), and nuclear medicine imaging including single photon emission computed tomography (SPECT) and positron emission tomography (PET). The history and physics behind how each of these imaging techniques came about will be discussed. The strengths and weaknesses of each imaging technique will also be covered in depth and **students will have an opportunity to participate in hands-on imaging demonstrations.** Engineering considerations will also be discussed on how to optimize these imaging techniques for specific biomedical applications.

NOTE: FALL 2020 Syllabus – there may be minor changes for fall 2021

BME 426: Basics of Biomedical Imaging: Ionizing Radiation

1. Basic Information:

Course:	BME 426, 2-units
Place and time:	Tuesday and Thursday; 4 hours per week (7 weeks total)
Faculty:	Cristina Zavaleta, Ph.D., Assistant Professor, BME Department
Office:	MCB 358
Email:	czavalet@usc.edu
Office Hours:	Wed 10:00 AM to 5:00 PM (by email appointment only)
TA:	TBD
TA email:	TBD
TA's Office Hours:	TBD

2. Course Description and Learning Objectives:

Description

Engineering, modern physics concepts and clinical-applications of ionizing radiation imaging techniques including: x-ray imaging, mammography, fluoroscopy, CT, and nuclear medicine imaging including SPECT and PET.

Expanded Description

Students will be introduced to various biomedical imaging methods that require the use of ionizing radiation sources. These include both clinical and preclinical imaging platforms: x-ray imaging including conventional radiography, mammography, fluoroscopy, computed tomography (CT), and nuclear medicine imaging including single photon emission computed tomography (SPECT) and positron emission tomography (PET). The history and physics behind how each of these imaging techniques came about will be discussed. The strengths and weaknesses of each imaging technique will also be covered in depth and **students will have an opportunity to participate in hands-on imaging demonstrations.** Engineering considerations will also be discussed on how to optimize these imaging techniques for specific biomedical applications.

Due to the hands on laboratory exercises in the professor's laboratory space, the class will be limited to 15 students per class. Two sessions will be offered each semester to accommodate student's schedules.

Prerequisite(s): PHYS 152L

Learning Outcomes

Outcome 1: Understand the underlying physics behind the most common clinical imaging modalities that utilize ionizing radiation, as well as several emerging preclinical imaging techniques: X-ray imaging, mammography, fluoroscopy, X-ray computed tomography (CT), single-photon emission computed tomography (SPECT) and positron emission tomography (PET).

Outcome 2: Have general knowledge of how biological components (parameters) of the human body lead to contrast in these common imaging modalities. Be able to relate physical and biological parameters to engineering design of imaging instruments.

Outcome 3: Have a working knowledge of the Fourier and Radon transforms, how they relate to the mathematical basis of image reconstruction, and how/when they can be employed.

Outcome 4: Be able to apply concepts associated with basic principles of ionizing radiation photons, including which detection elements are necessary and/or optimal for stopping high energy photons and converting them to an electronic signal that can then be used to construct an image.

Outcome 5: Be able to work as part of a team of students to complete a multi-week research project on current, state-of-the-art imaging applications, and share the results of the project through an oral presentation.

Outcome 6: Possess a broad knowledge of imaging technologies and the limitations or concerns associated with them in order to engage in further education or practice in the field.

3. Lecture Topics

- Radiation Physics/Interaction of Radiation with Matter
- Radiation Biology
- X-ray Imaging, Mammography and Fluoroscopy
- Computed Tomography
- Nuclear Medicine Imaging SPECT and PET
- Tomographic Image Reconstruction

Sub-Topics to be Covered within Each Imaging Modality

- Image quality
- Multimodal Imaging Capabilities
- Nano-based Contrast Agents
- Theranostic Potential

4. Text and Source Materials:

1. *The Essential Physics of Medical Imaging*. Jerrold T. Bushberg, J. Anthony Seibert, Edwin M. Leidholdt Jr., John M. Boone, 3rd edition, 2011.
2. BME 426 class slides. Download from Blackboard.
3. FIJI (ImageJ) Download https://imagej.net/Fiji/Downloads
4. AMIDE Download http://amide.sourceforge.net/index.html

5. Grading:

Special Project	20%
Journal Club Report	15%
Homework (2 Assignments)	30%
Final Exam	35%

If you wish to dispute a grade, you must do so within *two weeks* of the posting of that grade.

6. Exams:

You will be allowed to bring a calculator and ONE double-sided 8.5" by 11" note page for each exam. During an exam, please ask permission before leaving the room and do not take any electronic devices with you (phones, etc., should remain stored in your belongings until after the exam is over). A phone will not be allowed as a substitute for a calculator.

7. Special Project:

Assigned groups made up of 2-3 students will each prepare a 20-minute PowerPoint presentation on any ionizing radiation imaging related topic of their choice. Students will be put into groups on the first day of class. Groups will be expected to research the area in depth through google scholar or pubmed literature searches and/or press releases on the topic. This exercise is intended to give the students the opportunity to go into further depth on the biomedical applications of the imaging topics we've covered in class. At the same time, the rest of the class will have an opportunity to learn about how the imaging modalities we covered in class are being applied to various biomedical applications. This exercise offers a dual teaching/learning opportunity. A brief introduction on the imaging technique will be allowed, however the presentation is not intended to solely cover material that was already covered during the lectures. Groups must choose their topics by week 4 of the semester. Presentations will be made in week 7 of class.

Following each presentation, we will have a 10-minute class discussion where other students in the class will have an opportunity to ask questions to the presenting group members. I will also be asking questions to assess the group's comprehension and critical thinking skills on the imaging topic of interest.

8. Mock Journal Club:

The same groups from the special project will be assigned one biomedical imaging related journal article to review. Your group will write up a report on the article (no more than 3 pages). The report will summarize your thoughts on the article based on the topics/questions outlined on the first day of class. Journal club reports are due in week 5.

A slide deck will be issued to students on the first day of class to help them prepare the journal club report.

The following topics should be summarized in the report:

- Authors
- Background
- Research question
- Study design
- Results
- Conclusions
- Critical Thinking

The following metrics will be assessed:

Demonstrated research on the authors and their expertise in the field

Demonstrated comprehension in the field (understanding the background and significance)

Demonstrated comprehension of the study design

Demonstrated reasonable interpretation of results

Demonstrated critical thinking

9. Homework:

Homework will primarily consist of calculation and writing assignments along with **questions from laboratory exercises**. While you may consult with classmates regarding the homework assignments and on solution ideas, you are required to write your own homework reports. Homework solutions may not be shared. Plagiarism of another's work is a very serious offense and all suspected cases will be dealt with according to University regulations (see SCampus). It is also not acceptable to copy and paste your answers from the internet (or from the lecture notes).

Each of the homework assignments will be worth 15% of the overall grade which combines to 30% of the overall grade.

Homework assignments that require submission of a physical document are to be turned in at the beginning of class on the day they are due. For every day (or portion of a day) an assignment is late, 20% will be subtracted from its maximum point total.

10. Statement of Academic Integrity from SJACS*:

The University of Southern California is primarily an academic community. As such, the university seeks to maintain an optimal learning environment. It protects its educational environment by establishing and maintaining standards of conduct for its students. These standards reflect the very nature of an academic community and the need to preserve an effective educational environment. General principles of academic integrity include and incorporate the concept of respect for the intellectual property of others, the expectation that individual work will be submitted unless otherwise allowed, and the obligations to protect one's work from misuse by others as well as to avoid using another's work as one's own. All students are expected to understand and abide by these principles (*Scampus 2010*).

Students should be aware of the expectations as outlined in the Student Conduct Code found in *SCampus* online at http://web-app.usc.edu/scampus/university-governance/. In addition, USC Libraries provides an on-line tutorial for students to become familiar with standards: http://usccollege.na4.acrobat.com/academicintegrity.

11. Webpage:

This course uses Blackboard and can be accessed via:
https://blackboard.usc.edu/webapps/login/.
Be sure to CHANGE or FORWARD YOUR EMAIL to the one you use most frequently, as we will send out email messages during the semester using the email address that is associated with your account on the Blackboard website.

12. BME Program Outcomes:

* SJACS: Student Judicial Affairs and Community Standards

The BME program states that students successfully completing the program should have acquired the following outcomes:

1) an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
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 informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
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 meet objectives
6) an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
7) an ability to acquire and apply new knowledge as needed, using appropriate learning strategies

This table shows the correlation between course outcomes (Section 2) and student outcomes:

Course Outcomes↓ Student Outcomes →	1	2	3	4	5	6	7
Outcome 1:	x						
Outcome 2:	x	x					
Outcome 3:	x						
Outcome 4:	x	x				x	
Outcome 5:			x	x	x		
Outcome 6:							x
All Course Outcomes	x	x	x	x	x	x	x

13. Course Outline and Topics:

	Topics/Daily Activities	Readings/Preparation	Deliverables
Week 1 Aug 18 Aug 20	Introduction to Imaging Ionizing Radiation Physics Radiation Biology	Chapters 2, 3, and 20	
Week 2 Aug 25 Aug 27	X-ray Imaging **X-ray Attenuation Lab**	Chapters 6 and 7 Use of PubMed	**Assigned Journal Article Due Sept 22** **Assigned Homework 1 Due Sept 10**
Week 3 Sept 1 Sept 3	Mammography Imaging Fluoroscopy Imaging	Chapters 8 and 9	

Week 4 Sept 8 Sept 10	Computed Tomography Imaging Reconstruction **Hounsfield Unit CT Lab**	Chapter 10	**Project Present. Topics Due Sept 8** **Homework 1 Due Sept 10**
Week 5 Sept 15 Sept 17	Radionuclide Production Nuclear Medicine Imaging	Chapter 15-18	**Assigned Homework 2 Due Oct 1**
Week 6 Sept 22 Sept 24	SPECT and PET imaging **18F-FDG PET Lab**	Chapter 19	**Journal Club Reports Due Sept 22**
Week 7 Sept 29 Oct 1	Project Presentations on Biomedical Imaging Related Topic	Group Research on Biomedical Imaging Topic	**20 min Oral Presentations Sept 29** **Homework 2 Due Oct 1**
Final Exam Oct 6	Cumulative Exam on all lectures and labs	All topics covered in class	

As a 2-unit course that meets for 4-hr/wk for 7 weeks, USC policy states that the students are expected to spend roughly 8-hrs/wk of work/study outside of class. This time will be spent in preparing for lectures via reading/watching videos (from slide deck) and completing homework, labs, journal club reports, and preparing for their final project presentation.

Statement on Academic Conduct and Support Systems

Academic Conduct:

Plagiarism – presenting someone else's ideas as your own, either verbatim or recast in your own words – is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in SCampus in Part B, Section 11, "Behavior Violating University Standards" policy.usc.edu/scampus-part-b. Other forms of academic dishonesty are equally unacceptable. See additional information in SCampus and university policies on scientific misconduct, policy.usc.edu/scientific-misconduct.

Support Systems:

Counseling and Mental Health - (213) 740-9355 – 24/7 on call
studenthealth.usc.edu/counseling
Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention.

National Suicide Prevention Lifeline - 1 (800) 273-8255 – 24/7 on call
suicidepreventionlifeline.org
Free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week.

Relationship and Sexual Violence Prevention and Services (RSVP) - (213) 740-9355(WELL), press "0" after hours – 24/7 on call
studenthealth.usc.edu/sexual-assault
Free and confidential therapy services, workshops, and training for situations related to gender-based harm.

Office of Equity and Diversity (OED)- (213) 740-5086 | Title IX – (213) 821-8298
equity.usc.edu, titleix.usc.edu
Information about how to get help or help someone affected by harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants. The university prohibits discrimination or harassment based on the following *protected characteristics*: race, color, national origin, ancestry, religion, sex, gender, gender identity, gender expression, sexual orientation, age, physical disability, medical condition, mental disability, marital status, pregnancy, veteran status, genetic information, and any other characteristic which may be specified in applicable laws and governmental regulations. The university also prohibits sexual assault, non-consensual sexual contact, sexual misconduct, intimate partner violence, stalking, malicious dissuasion, retaliation, and violation of interim measures.

Reporting Incidents of Bias or Harassment - (213) 740-5086 or (213) 821-8298
usc-advocate.symplicity.com/care_report
Avenue to report incidents of bias, hate crimes, and microaggressions to the Office of Equity and Diversity |Title IX for appropriate investigation, supportive measures, and response.

The Office of Disability Services and Programs - (213) 740-0776
dsp.usc.edu
Support and accommodations for students with disabilities. Services include assistance in providing readers/notetakers/interpreters, special accommodations for test taking needs, assistance with architectural barriers, assistive technology, and support for individual needs.

USC Support and Advocacy - (213) 821-4710
uscsa.usc.edu
Assists students and families in resolving complex personal, financial, and academic issues adversely affecting their success as a student.

Diversity at USC - (213) 740-2101
diversity.usc.edu
Information on events, programs and training, the Provost's Diversity and Inclusion Council, Diversity Liaisons for each academic school, chronology, participation, and various resources for students.

USC Emergency - UPC: (213) 740-4321, HSC: (323) 442-1000 – 24/7 on call
dps.usc.edu, emergency.usc.edu
Emergency assistance and avenue to report a crime. Latest updates regarding safety, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible.

USC Department of Public Safety - UPC: (213) 740-6000, HSC: (323) 442-120 – 24/7 on call
dps.usc.edu
Non-emergency assistance or information.