# San José State University
# College of Engineering
# Biomedical, Chemical and Materials Engineering

# BME 258, Medical Imaging for Engineers, Spring 2019

## Course and Contact Information

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| **Instructor:** | Hamed Salehizadeh |
| **Office Location:** | BME Conference Room, 233-O |
| **Telephone:** | TBA |
| **Email:** | hamed.salehizadeh@sjsu.edu |
| **Office Hours:** | R 17:00-18:00 |
| **Class Days/Time:** | Thursday 18:00-19:45, |
| **Classroom:** | Lecture DMH162 and Lab ENG339 |
| **Computer laboratory** | Saturday 9:00-11:45 |
| **Prerequisites:** | **Phys 51, or equivalent. Math 133A or equivalent. BME 177, or equivalent. BME 210, or equivalent. Instructor consent.** |

## Course Format

The course adopts a hybrid approach, alternating lecture-based and flipped classroom delivery formats. iClicker or equivalent technology will be used to foster in-class discussion and interaction. Students must have internet-connected devices (laptops, tablets or equivalent) in order to fully participate to classroom activities. Computer-based learning activities will be held weekly and will be based on free open-source software, such as ImageJ (image analysis) and R (statistics), as well as commercial software available in the computer-equipped classrooms (MATLAB).

## Faculty Web Page and MYSJSU Messaging

Course materials such as syllabus, handouts, notes, assignment instructions, etc. can be found on the Canvas learning management system course website. All communications relevant to the course will be sent out using the Canvas messaging system (Canvas email and announcement board). You are responsible for regularly checking with the messaging system through Canvas to learn of any updates.

## Course Piazza Site

A link to the course Piazza site is provided on Canvas. Piazza is the fastest way for you to ask technical questions to the professor while allowing them to share their response to all students at once. You may post questions anonymous to other students (professor will see who you are). Students may also answer your questions, endorse responses made by other students, and mark duplicate questions.

To ensure fair treatment of all students and to provide students with the most rapid and consistent instructional information, **the professor will not answer technical and policy questions by email.** Technical and policy

questions include those regarding homework content, exam content, assignment deadlines, etc. Students should instead post to the class discussion board on Piazza.

**Email Policy**
Please send **emails regarding personal issues** (academic integrity issues, personal grades, medical issues, etc.) to the professor and/or TA. To receive the most rapid response to your email message, please start the subject line with the characters "**BME258**". Out of fairness to all students, email communications related to technical questions or course policy will *not* be returned (please post these types of questions to the course Piazza site).

## Course Description

An introduction to the principles and clinical applications of medical imaging. Fundamentals of digital image acquisition and manipulation. Physical principles: interaction of radiation with matter. Image resolution, quality and artifacts. Clinical imaging techniques: X-ray planar radiography and computed tomography, ultrasound imaging, magnetic resonance imaging. Safety of medical imaging. Computer laboratory: clinical image analysis; image enhancement, segmentation, contouring; feature recognition.

## Learning Outcomes

The fundamental objectives of this course are (a) to introduce students to the underlying physics, mathematics and engineering concepts of modern medical imaging, and (b) to have the students learn how medical images are collected and processed and how they can be used for diagnosis and therapy.

### *Learning objectives*

- understand the basic physical concepts of how biological components of our bodies lead to contrast in medical images.
- describe the major components of most standard medical imaging systems, including radiography, computed tomography, ultrasound, and magnetic resonance imaging systems.
- obtain a basic understanding of how data are acquired by each scanner, how data are processed, how images are reconstructed, how these data are analyzed and how the results are interpreted
- identify the preferred medical imaging methods for routine clinical applications.
- understand the biologic effects of the different types of radiation and contrast agents used in medical imaging and discuss principles and issues of safety of medical imaging.
- compare and contrast the role of different imaging modalities in providing anatomical and physiological information about the human body within limits imposed by the physical and engineering design constraints of each modality.
- solve qualitative and quantitative problems related to medical image acquisition
- assess quality and artifact issues of medical images acquired from different techniques.
- analyze medical images utilizing basic image processing techniques, including image enhancement, segmentation and contouring.
- analyze and criticize peer-reviewed publications on medical imaging.

## Required Texts/Readings

### *Textbook*

Nadine B. Smith and Andrew Webb, Introduction to Medical Imaging: Physics, Engineering and Clinical Applications, 1st Edition, Cambridge University Press (2010).

### *Other Readings*

- Paul Suetens, Fundamentals of Medical Imaging, 2nd Edition, Cambridge University Press (2009).
- Jerry L. Prince and Jonathan Links, Medical Imaging Signals and Systems, 2nd Edition, Prentice Hall (2014).

## Library Liaison (Biomedical, Chemical & Materials Engineering Department)

Anamika Megwalu, Ph.D.
Phone: (408) 808-2089
Email: anamika.megwalu@sjsu.edu

## Course Requirements and Assignments

SJSU classes are designed such that in order to be successful, it is expected that students will spend a minimum of forty-five hours for each unit of credit (normally three hours per unit per week), including preparing for class, participating in course activities, completing assignments, and so on. More details about student workload can be found in University Policy S12-3 at http://www.sjsu.edu/senate/docs/S12-3.pdf.

Attainment of the learning objectives (as listed above) will be assessed via homework and in-class assignments, group-based computer laboratories, two mid-term examinations, and the final examination.

### *Assignments*

Lecture-based homework will be handed out biweekly, and must be submitted **individually** on the due date. Late assignments will not be accepted. The lowest lecture homework score of the semester will be dropped. Occasionally, group assignment will be scheduled at the beginning of class.

Laboratory-based assignment can be done **in groups of 3-4 students**. Homework must be submitted on the due date. Late assignments will lose 10% per day.

### *Examinations*

There will be two mid-semester examinations, and one final examination. Each examination will cover the entire course material covered until the time of the examination. The dates of the mid-semester examinations are indicated in the Lecture Schedule. The final examination will be held on the date specified by the university's final examination schedule**.** There will be no make-up examinations.

### *Journal Club*

Throughout the semester there will be three special classes dedicated to discussing three peer-reviewed articles on computed tomography, ultrasound imaging, and magnetic resonance imaging. All the students will read the assigned paper prior to class. For each class, after a general discussion of the content and merit of the paper, the class will break out in **groups of 3-4** students and begin working on a report on the paper, to be completed as a group assignment at home and submit it within one week. Late assignments will lose 10% per day.

***MOSS Code Checking***
MATLAB code written for homework, lab, and/or exam questions is subject to plagiarism checking using the MOSS software (http://theory.stanford.edu/~aiken/moss/). This tool checks MATLAB code for excessive similarity against both the internet *and* code submitted by other classmates. Code that is flagged by the program and confirmed by the instructor to be excessively similar will receive a zero-score and subject to the SJSU academic integrity process. Students are free to download their own copies of the software to compare their code prior to submission.

NOTE that University policy F69-24 at http://www.sjsu.edu/senate/docs/F69-24.pdf states that "Students should attend all meetings of their classes, not only because they are responsible for material discussed therein, but because active participation is frequently essential to insure maximum benefit for all members of the class. Attendance per se shall not be used as a criterion for grading."

## Grading Policy

***Letter Grades:***

A: approx. 90% ~ 100%
B: approx. 80% ~ 90%
C: approx. 70% ~ 80%
D: approx. 60% ~ 70%
F: < 60%

Note: +/- grades may be used at the instructor's discretion.

***Weight of class assignments and examinations:***

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|---|---|
| Midterm examination I | 15% |
| Midterm examination II | 15% |
| Final Examination | 30% |
| Lecture-based Assignment | 10% |
| Laboratory-based Assignment | 20% |
| Journal Club Reports | 10% |

Absence during examinations and quizzes, without prior approval, will result in a zero. Prior approval will be given only under exceptional circumstances.

Note that "All students have the right, within a reasonable time, to know their academic scores, to review their grade-dependent work, and to be provided with explanations for the determination of their course grades." See University Policy F13-1 at http://www.sjsu.edu/senate/docs/F13-1.pdf for more details.

## Classroom Protocol

***Attendance and arrival times***

Students are expected to be set up for lecture by the time the class begins. Attendance in class is not mandatory and shall not be used per se as a criterion for grading. However class attendance and participation are highly recommended.

***Behavior***

Students should remain respectful of each other at all times. Interruptive or disruptive attitudes are discouraged. While in the classroom, the use of electronic devices (laptops, tablets, smartphones) should be limited to

activities closely related to the learning objectives. While in the classroom, electronic devices should not be used for personal communication, included messaging and use of social media. All cell phones must be silenced prior to entering the classroom.

### *Assignments*

Students are encouraged to collaborate on all types of assignments. However, lecture-based assignments must be individually prepared and submitted by each student.

### *Safety*

Students should familiarize themselves with all emergency exits and evacuation plans. Especially since class concludes in the evening, when departing the building, students should be aware of their surroundings, and carry a cell phone.

## University Policies

### *Dropping and Adding*

Students are responsible for understanding the policies and procedures about add/drop, grade forgiveness, etc. Refer to the current semester's Catalog Policies section at http://info.sjsu.edu/static/catalog/policies.html. Add/drop deadlines can be found on the current academic year calendars document on the Academic Calendars webpage at http://www.sjsu.edu/provost/services/academic_calendars/. The Late Drop Policy is available at http://www.sjsu.edu/aars/policies/latedrops/policy/**.** Students should be aware of the current deadlines and penalties for dropping classes.

Information about the latest changes and news is available at the Advising Hub at http://www.sjsu.edu/advising/.

### *Consent for Recording of Class and Public Sharing of Instructor Material*

University Policy S12-7, http://www.sjsu.edu/senate/docs/S12-7.pdf, requires students to obtain instructor's permission to record the course and the following items to be included in the syllabus:

- "Common courtesy and professional behavior dictate that you notify someone when you are recording him/her. You must obtain the instructor's permission to make audio or video recordings in this class. Such permission allows the recordings to be used for your private, study purposes only. The recordings are the intellectual property of the instructor; you have not been given any rights to reproduce or distribute the material."
    - It is suggested that the greensheet include the instructor's process for granting permission, whether in writing or orally and whether for the whole semester or on a class by class basis.
    - In classes where active participation of students or guests may be on the recording, permission of those students or guests should be obtained as well.
- "Course material developed by the instructor is the intellectual property of the instructor and cannot be shared publicly without his/her approval. You may not publicly share or upload instructor generated material for this course such as exam questions, lecture notes, or homework solutions without instructor consent."

### *Academic integrity*

Your commitment, as a student, to learning is evidenced by your enrollment at San Jose State University. The University Academic Integrity Policy S07-2 at http://www.sjsu.edu/senate/docs/S07-2.pdf requires you to be honest in all your academic course work. Faculty members are required to report all infractions to the office of

Student Conduct and Ethical Development. The Student Conduct and Ethical Development website is available at http://www.sjsu.edu/studentconduct/.

### *Campus Policy in Compliance with the American Disabilities Act*

If you need course adaptations or accommodations because of a disability, or if you need to make special arrangements in case the building must be evacuated, please make an appointment with me as soon as possible, or see me during office hours. Presidential Directive 97-03 at http://www.sjsu.edu/president/docs/directives/PD_1997-03.pdf requires that students with disabilities requesting accommodations must register with the Accessible Education Center (AEC) at http://www.sjsu.edu/aec to establish a record of their disability.

### *Accommodation to Students' Religious Holidays*

San José State University shall provide accommodation on any graded class work or activities for students wishing to observe religious holidays when such observances require students to be absent from class. It is the responsibility of the student to inform the instructor, in writing, about such holidays before the add deadline at the start of each semester. If such holidays occur before the add deadline, the student must notify the instructor, in writing, at least three days before the date that he/she will be absent. It is the responsibility of the instructor to make every reasonable effort to honor the student request without penalty, and of the student to make up the work missed. See University Policy S14-7 at http://www.sjsu.edu/senate/docs/S14-7.pdf.

# BME 258 / Medical Imaging for Engineers, Fall 2017

## Tentative Course Schedule

***(subject to change with fair notice)***

| | Session | Date | Day | Lecture topics, examinations, lab activities | Recommended Reading |
|---|---|---|---|---|---|
| Week 1 | Lec1 | Jan-24 | *R* | Medical Imaging; Survey of Imaging Modalities Class Overview; | Nadine Ch. 1 |
| | *Lab0* | *Jan-26* | *S* | *No lab this week* | |
| Week 2 | Lec2 | Jan-31 | *R* | Image Resolution and Quality; Image Artifacts; Image Processing | Nadine Ch. 1.4-1.6; (Suetens Ch. 1) |
| | Lab1 | Feb-02 | *S* | Image Spatial Resolution; Brightness resolution; Color Conversion | |
| Week 3 | Lec3 | Feb-07 | *R* | Physical Principles: Interaction of radiation with matter | Nadine Ch. 2.4 (Suetens Ch. 2) |
| | Lab2 | Feb-09 | *S* | Contrast and Dynamic Range; Signal-to-Noise-Ratio; Gray-Level-Histograms | |
| Week 4 | Lec4 | Feb-14 | *R* | X-Ray Planar Radiography: Physical Principles, clinical applications, safety | Nadine Ch. 2.1-2.3, 2.5, 2.8-2.9, 2.10 (Suetens Ch. 2) |
| | Lab3 | Feb-16 | *S* | Image Enhancement in the Spatial Domain | |
| Week 5 | Lec5 | Feb-21 | *R* | Compute Tomography: Physical principles, clinical applications, safety | Nadine Ch. 2.12-2.18 (Suetens Ch. 3) |
| | Lab4 | Feb-23 | *S* | Radiographic Images; CT Images | |
| Week 6 | **Lec6** | **Feb-28** | ***R*** | **Midterm 1** | |
| | *Lab5* | *Mar-02* | *S* | *Journal Club 1* | |
| Week 7 | Lec7 | Mar-07 | *R* | Nuclear Medical Imaging; Radionuclides; Interaction with Tissues | Nadine Ch. 3.1-3.5 (Suetens Ch. 5) |
| | Lab6 | Mar-09 | *S* | Image Enhancement in the Frequency Domain - Part I | |
| Week 8 | Lec8 | Mar-14 | *R* | Nuclear Medical Imaging Modalities and Clinical Applications; Safety Issues | Nadine Ch. 3.8, 3.12, 3.21 |
| | Lab7 | Mar-16 | *S* | Image Enhancement in the Frequency Domain - Part II | |
| Week 9 | Lec9 | Mar-21 | *R* | Ultrasound Imaging: Physics of Acoustic Waves | Nadine Ch. 4.1-4.4 (Suetens Ch. 6) |
| | Lab8 | Mar-23 | *S* | Morphological Image Processing | |
| Week 10 | Lec10 | Mar-28 | *R* | Ultrasound Imaging Modalities and Clinical Applications; Safety Issues | Nadine Ch. 4.5-4.8, 4.13 |
| | Lab9 | Mar-30 | *S* | Ultrasound Images; Doppler Ultrasound Images | |
| Week 11 | *Lec 11* | *Apr-04* | | *Spring Recess* | |
| | **Lab 10** | **Apr-06** | **S** | **Midterm 2** | |

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| Week 12 | Lec11 | Apr-11 | R | Magnetic Resonance Imaging: Magnetic Fields and Interactions with Tissue | Nadine Ch. 5.1-5.7 (Suetens Ch. 4) |
| | *Lab10* | *Apr-13* | *S* | *Journal Club 2* | |
| Week 13 | Lec12 | Apr-18 | *R* | Application of Machine Learning in Medical Imaging | |
| | Lab11 | Apr-20 | S | Machine Learning and Deep Learning – Part 1 | |
| Week 14 | Lec13 | Apr-25 | *R* | Magnetic Resonance Imaging: Image Acquisition and Reconstruction; Sequences; Image Quality | Nadine Ch. 5.8-5.13, 5.20 (Suetens Ch. 4) |
| | Lab12 | Apr-27 | *S* | Image Segmentation | |
| Week 15 | Lec14 | May-02 | R | Magnetic Resonance Imaging: Clinical Applications; Safety Issues | Nadine Ch. 5.21-5.23 |
| | Lab13 | May-04 | S | Machine Learning and Deep Learning – Part 2 | |
| Week 16 | Lec15 | May-09 | *R* | Review | |
| | Lab14 | May-11 | *S* | Final Project | |
| | **FINAL** | **May-16** | ***R*** | **Final Exam 17:15-19:30** | |