Syllabus

NEUR 592 | BIOL 691 | BINF 739

Medical Imaging: Physical and Biological Principles

Spring Semester 2021

Weekly schedule**:** Each week runs from Monday (12:01 am) to Sunday (11:59 pm) starting on January 25th, 2021.

Instructor: Frank Krueger, Ph.D.
Department: School of Systems Biology
Phone: 703-993-4358
Email: fkrueger@gmu.edu (preferred)
Office Hours: By appointment (via Zoom)

Course Description

Medical imaging refers to a set of techniques and processes for creating visual representations of structure and functionality of various human body parts or tissues for scientific research as well as diagnostic and treatment purposes. This course covers the physical and biological principles of medical imaging approaches. On the one hand, it incorporates imaging technologies such as X-ray radiography, magnetic resonance imaging, ultrasound, and nuclear medicine functional imaging designed to produce images; on the other hand, it includes measurement and recording technologies (e.g., electroencephalography, magnetoencephalography) that produce representations about measurement locations. The course consists of four building blocks that serve as key components for an introduction into the field of medical imaging:

- **Building block 1** provides an overview about the *scientific imaging principles*, including image essentials such as what is an image, how to make an image, and how to analyze an image.
- **Building block 2** offers brief overviews about the *advantages and disadvantages of major medical imaging modalities*, including X-ray radiography, fluoroscopy, positron emission tomography (PET), single-photon emission computed tomography (SPECT), magnetic particle imaging (MPI), ultrasound, photoacoustic imaging, infrared spectroscopy, electroencephalography (EEG), and magnetoencephalography (MEG).
- **Building block 3** presents a detailed explanation of one imaging approach —*functional magnetic resonance imaging (fMRI)*— which covers exemplary the key components common in understanding other medical imaging approaches, including basic physical principles (e.g., signal generation, image formation), biological principles (e.g., origins, properties), experimental procedure (e.g., design, samples), and statistical analyses (e.g., descriptive, inferential).
- **Building block 4** includes the *planning and write-up of a research project* —i.e., project overview; background and gap of knowledge; project goal and hypothesis; experimental design and procedure; and data acquisition and analysis— that focuses on a selected imaging approach.

Learning outcomes

By the end of this course, students will be able to:

1. Understand the principles of scientific imaging (e.g., definition, production, and analysis of an image);
2. Evaluate the advantages and disadvantages of major medical imaging modalities (e.g., X-ray, PET, MRI, EEG, MEG);
3. Describe in detail the physical and biological principles, experimental design and procedure, and data acquisition and analyses of fMRI as an exemplary for common components in understanding other imaging methods; and
4. Develop a research project focusing on one of the presented imaging methods.

Prerequisite

This course is essential for anyone interested in the rapidly developing field of medical imaging Prerequisites are the completion or concurrent enrollment in all other required general education courses or permission of the instructor.

Textbook & Course Materials

Required Text

- Huettel, S.A. Song, AW., & McCarthy, G. (2014, 3rd edition). *Functional Magnetic Resonance Imaging*.

Recommended Texts & Other Readings

- Bryan, N. (ed.) (2009). *Introduction to the Science of Medical Imaging*.
- Other readings will be made available in Blackboard (See Learning Modules).

Course Logistics

This course will use a distance learning format; the primary meeting space will be on Blackboard 9.1; and we will use other means of keeping in touch such as email, telephone, and Blackboard Collaborate Ultra. This is a rigorous course: you will accomplish the following activities in a typical week:

- Reading about 35-50 pages, reflecting the content, and discussing the material with your classmates;
- Completing on-line activities and responding to weekly requirements; and
- Working on assignments completing in Blackboard according to the assignment schedule.

Though the delivery method is different, it should take you the same amount to time as a typical full-semester course. You should **expect to spend approximately 9 hours on coursework each week** (this includes the time you would have spent in a classroom). It is critical to keep up with weekly requirements. Each week, I will provide an announcement and module in our Blackboard course to specify required activities and assignments (available by clicking on 'Announcements' or 'Weekly Modules' on the course menu in Blackboard).

Blackboard (Available on January 25th, 2021)

We will use Blackboard for the course. Additional guidance on individual assignments and discussion questions will be posted there. All assignments will be submitted through Blackboard for grading. Please visit our Blackboard site regularly.

Access Blackboard by following these steps:

1. Go to http://mymason.gmu.edu.
2. Log in using your NETID and password,
3. Click on the 'Courses" tab.
4. Click on 'Medical Imaging (NEUR 592 | BIOL 691 | BINF 739 | Spring 2021)' under the 'Course List' heading.

Instructor-Student Communication

I will respond to your emails from Monday (9 am) through Friday (6 pm) within 24 hours. If I am away from email for more than two days, I will post an announcement in the Blackboard course folder.

Before sending an email with questions, please check the following (available on your Blackboard course menu) **unless the email is of a personal nature**:

- Syllabus,
- Ask the Professor (Feel free to respond to other students in the Help forum if you know the answer.),
- Blackboard Tutorials on how to use Blackboard features,
- Blackboard Q&A (resources specific to Mason), and
- Technology Requirements.

Mason EMAIL

- Mason requires that Mason email be used for all courses. I will be sending messages to your Mason email, and you are responsible for making sure you have access to these messages.
- You may forward your Mason email to other accounts but always use your Mason e-mail when communicating with me to allow verification of your identity.
- You are required to check your Mason email account regularly and to keep your mailbox maintained so that messages are not rejected for being over quota.
- When you email me, you can expect a response within 24 hours (*Monday through Friday*). If I am going to be away from email for more than two days, I will send an announcement to the class.
- When you email me, be sure to include '**MED IMAG NEUR 592, BIOL 691, or BINF 739'** at the beginning of the subject heading to alert me that I have received a message from one of my online students.

Participation

Netiquette For Online Discussions [1]: Our discussion should be collaborative, not combative; you are creating a learning environment, sharing information and learning from one another. Respectful communication is essential to your success in this course and as a professional. Please re-read your responses carefully before you post them so others will not take them out of context or as personal attacks. Be positive to others and diplomatic with your words and I will try my best to do the same. Be careful when using sarcasm and humor. Without face-to-face communications, your joke may be viewed as criticism. Experience shows that even an innocent remark in the online environment can be easily misconstrued.

Netiquette prepared by Charlene Douglas, Associate Professor, College of Health & Human Services, GMU.

Technology Requirements

Technology requirements for the course are:

- Internet connection (DSL, LAN, or cable connection desirable);
- PC desktop/ laptop with microphone headset;
- Supported Web browser (e.g., Internet Explorer, Chrome, Safari) to use Adobe Connect for Live Class Sessions; and
- MS Office 365 ProPlus provided at no cost via the Microsoft Student Advantage Program (Access is tied to your @masonlive.gmu.edu email address).

Student Responsibilities

MasonLive/Email

Students are responsible for the content of university communications sent to their George Mason University email account and are required to activate their account and check it regularly. For accessibility and privacy, the university, school, and program will send communications to students solely through their Mason email account—students should respond accordingly (See Masonlive login information).

Patriot Pass

Once you sign up for your Patriot Pass, your passwords will be synchronized, and you will use your Patriot Pass username and password to log in to the following systems: Blackboard, University Libraries, MasonLive, myMason, Patriot Web, Virtual Computing Lab, and WEMS. (See password).

Students with Disabilities

Students with disabilities who seek accommodations in a course must be registered with the George Mason University Office of Disability Services (ODS) and inform their instructor, in writing, at the beginning of the semester (See Office of Disability Services).

Academic Integrity

Students must be responsible for their work, and students and faculty must take on the responsibility of dealing explicitly with violations. The tenet must be a foundation of our university culture (See Office of Academic Integrity).

Honor Code and Virtual Classroom Conduct

Students must adhere to the guidelines of the George Mason University Honor Code (See Honor Code).

We value critical thinking and therefore, it is imperative that students read the assigned material (e.g., books, articles) before the class with a critical eye. Active thought, quality of inputs, and a conflict resolution attitude should be your guiding principles.

The principle of academic integrity is taken very seriously, and violations are treated gravely. What does academic integrity mean in this course? Essentially this: when you are responsible for a task, you will perform that task. When you rely on someone else's work in an aspect of the performance of that task, you will give full credit in the proper, accepted form.

Another aspect of academic integrity is the free play of ideas. Vigorous discussion and debate are encouraged in this course, with the firm expectation that all aspects of the class will be conducted with civility and respect for differing ideas, perspectives, and traditions. When in doubt (of any kind) please ask for guidance and clarification.

Plagiarism is the equivalent of intellectual robbery and cannot be tolerated in the academic setting. If you have any doubts about what constitutes plagiarism, please contact me.

University Policies

Students must follow university policies (See University Policies).

Responsible Use of Computing

Students must follow the university policy for Responsible Use of Computing (See Responsible User of Computing).

University Calendar

Details regarding the current Academic Calendar (See Calendar).

University Catalog

Details regarding the current university catalog (See University Catalog).

Student Services

Writing Center

The George Mason University Writing Center staff provides a variety of resources and services (e.g., tutoring, workshops, writing guides, handbooks) intended to support students as they work to construct and share knowledge through writing (See Writing Center). ESL Help: The

program was designed specifically for students whose first language is not English who feel they might benefit from additional, targeted support throughout an entire semester (See Writing Center).

University Libraries

University Libraries provides resources for distance students (See Library).

Counseling and Psychological Services

The George Mason University Counseling and Psychological Services (CAPS) staff consists of professional counseling and clinical psychologists, social workers, and counselors who offer a wide range of services (e.g., individual and group counseling, workshops, and outreach programs) to enhance students' personal experience and academic performance (See CAPS).

Family Educational Rights and Privacy Act (FERPA)

The Family Educational Rights and Privacy Act of 1974 (FERPA), also known as the "Buckley Amendment," is a federal law that gives protection to student educational records and provides students with certain rights (See FERPA).

Weekly Schedule

Distance learning courses are dynamic—to ensure we achieve our learning outcomes— we may need to negotiate weekly schedule changes. We will focus on learning, fairness, and reason for any approved changes. Each week's activities —reading assignments about topics, watching videos and reflecting on neuroscience methods (via a blog), defining key concepts (via a glossary), testing your knowledge about brain anatomy (via a quiz), and sharing and discussing your knowledge with classmates (via discussion forum)— **requires approximately 9 hours.**

The table below lists the weekly schedule, major activities, major assignments, points, and due dates for this course. Final grades will be based on the total number of points earned in the course.

Weeks	**Major Topics and Methods**	**Assignments (graded)**	**Points**	**Due Dates (11.59 pm, EST)**
Week 1 Monday, Jan. 25 — Sunday, Jan. 31	I. IMAGING ESSENTIALS Topic: What is an image? Project: Overview	Introduce Yourself Orientation Quiz Topic: Discussion (Part 1) Topic: Glossary Topic: Discussion (Part 2) Project: Write-up	5 5 5 5 5 10	Wednesday, 01/27 Sunday, 01/31
Week 2 Monday, Feb. 1 — Sunday, Feb. 7	I. IMAGING ESSENTIALS Topic: How to make an image Project: Background	Topic: Discussion (Part 1) Topic: Glossary Topic: Discussion (Part 2) Project: Write-up	5 5 5 10	Wednesday, Feb. 3 Sunday, Feb. 7

Week 3 Monday, Feb. 8 — Sunday, Feb. 14	I. IMAGING ESSENTIALS Topic: How to analyze an image Project: Gap of Knowledge	Topic: Discussion (Part 1) Topic: Glossary Topic: Discussion (Part 2) Project: Write-up	5 5 5 10	Wednesday, Feb. 10 Sunday, Feb. 14
Week 4 Monday, Feb. 15 — Sunday, Feb. 21	II. EXEMPLARY IMAGING METHOD — FMRI Topic: Introduction to fMRI Project: Goal	Topic: Discussion (Part 1) Topic: Glossary Topic: Discussion (Part 2) Project: Write-up	5 5 5 10	Wednesday, Feb. 17 Sunday, Feb. 21
Week 5 Monday, Feb. 22 — Sunday, Feb. 28	II. EXEMPLARY PHYSICAL PRINCIPLES — FMRI Topic: Basic Principles of MR Signal Generation Method: X-ray Project: Hypothesis	Topic: Discussion (Part 1) Topic: Glossary Method: Reflection Topic: Discussion (Part 2) Project: Write-up	5 5 10 5 10	Wednesday, Feb. 24 Sunday, Feb. 28
Week 6 Monday, Mar. 1 — Sunday, Mar. 7	II. EXEMPLARY PHYSICAL PRINCIPLES — FMRI Topic: Basic Principles of MR Image Formation Method: Fluoroscopy Project: Sample	Topic: Discussion (Part 1) Topic: Glossary Method: Reflection Topic: Discussion (Part 2) Project: Write-up	5 5 10 5 10	Wednesday, Mar. 3 Sunday, Mar. 7
Week 7 Monday, Mar. 8 — Sunday, Mar. 14	II. EXEMPLARY PHYSICAL PRINCIPLES — FMRI Topic: MRI Contrast Mechanisms and Acquisition Techniques Method: PET Project: Experimental Design	Topic: Discussion (Part 1) Topic: Glossary Method: Reflection Topic: Discussion (Part 2) Project: Write-up	5 5 10 5 10	Wednesday, Mar. 10 Sunday, Mar. 14
Week 8 Monday, Mar. 15 — Sunday, Mar. 21	II. EXEMPLARY BIOLOGICAL PRINCIPLES — FMRI Topic: From Neuronal to Hemodynamic Activity Method: SPECT Project: Experimental Procedure	Topic: Discussion (Part 1) Topic: Glossary Method: Reflection Topic: Discussion (Part 2) Project: Write-up	5 5 10 5 10	Wednesday, Mar. 17 Sunday, Mar. 21
Week 9 Monday, Mar. 22 — Sunday, Mar. 28	II. EXEMPLARY BIOLOGICAL PRINCIPLES — FMRI Topic: BOLD fMRI: Origins and Properties Method: Ultrasound Project: Image Acquisition	Topic: Discussion (Part 1) Topic: Glossary Method: Reflection Topic: Discussion (Part 2) Project: Write-up	5 5 10 5 10	Wednesday, Mar. 24 Sunday, Mar. 28
Week 10 Monday, Mar. 29 — Sunday, Apr. 4	II. EXEMPLARY DATA PREPREATION — FMRI Topic: Signal, Noise, and Preprocessing of fMRI Data Method: Photoacoustic imaging Project: Physical Principle	Topic: Discussion (Part 1) Topic: Glossary Method: Reflection Topic: Discussion (Part 2) Project: Write-up	5 5 10 5 10	Wednesday, Mar. 31 Sunday, Apr. 4
Week 11 Monday, Apr. 5 — Sunday, Apr. 11	II. EXEMPLARY EXPERIMENTAL PROCEDURE — FMRI Topic: Experimental Design Method: Magnetic particle imaging Project: Biological Principle	Topic: Discussion (Part 1) Topic: Glossary Method: Reflection Topic: Discussion (Part 2) Project: Write-up	5 5 10 5 10	Wednesday, Apr. 7 Sunday, Apr. 11

Week 12 Monday, Apr. 12 — Sunday, Apr. 18	II. EXEMPLARY DATA ANALYSIS — FMRI Topic: Statistical Analysis I: Basic Analyses Method: Infrared spectroscopy Project: Data Acquisition	Topic: Discussion (Part 1) Topic: Glossary Method: Reflection Topic: Discussion (Part 2) Project: Write-up	5 5 10 5 10	Wednesday, Apr. 14 Sunday, Apr. 18
Week 13 Monday, Apr. 19 — Sunday, Apr. 25	II. EXEMPLARY DATA ANAYLSIS — FMRI Topic: Statistical Analysis II: Advanced Approaches Method: Electroencephalography Project: Data Analysis Course: Online Course Evaluation	Topic: Discussion (Part 1) Topic: Glossary Method: Reflection Topic: Discussion (Part 2) Project: Write-up Course: Evaluation	5 5 10 5 10 20	Wednesday, Apr. 21 Sunday, Apr. 25
Week 14 Monday, Apr. 26 — Sunday, May 2	II. EXEMPLARY PRACTICAL AND ETHICA ISSUES — FMRI Topic: The Future of fMRI: Practical and Ethical Issues Method: Magnetoencephalography Project: Revision	Topic: Discussion (Part 1) Topic: Glossary Method: Reflection Topic: Discussion (Part 2) Project: Write-up	5 5 10 5 25	Wednesday, Apr. 28 Sunday, May 2
			Total 500	

Grading Scale (points)

Final grades assigned for this course will be based on the percentage of total points earned and are assigned as shown in the table. Remember, that grades are not given be my; they are earned by you.

Letter Grade	Percentage	Points	Performance
A^+	98-100%	490-500	Superb Work
A	93-97%	465-485	Excellent Work
A^-	90-92%	450-460	Nearly Excellent Work
B^+	87-89%	435-445	Very Good Work
B	83-86%	415-430	Good Work
B^-	80-82%	400-410	Mostly Good Work
N/A	<80%	<400	Failing Work