**BENG/ECE 538: Medical Imaging**  
**Fall 2017**

**Credits 3**  
Tuesdays, 1:30 pm – 4:10 pm, Room: Research Hall 202

**Instructor:**  
Parag V. Chitnis, PhD  
Assistant Professor  
Department of Bioengineering  
Office: Engineering, Room 3908  
Email: pchitnis@gmu.edu  
Phone: 703-993-5039  
Office hours: Thursday 4:00-5:00 PM and by appointment

**Course description:**  
This course will provide an introduction to the physical, mathematical and engineering foundations of modern medical imaging instruments and imaging physics principles that enable us to “see” inside the human body to diagnose disease, monitor treatment and perform minimally-invasive interventions. The emphasis will be on diagnostic ultrasound and MRI imaging methods, although several other modalities will also be discussed. The course will also provide an overview of recent developments in the field of medical imaging and discuss some of the challenges and controversies. The students will get hands on experience in applying the methods learnt in class to real-world problems and imaging data. There will be broad scope to individually and collaboratively explore current problems in medical imaging.

**Learning objectives:**  
1. Demonstrate a strong grasp of the basic physical principles underlying several medical imaging modalities.  
2. Demonstrate a solid understanding of the concepts of medical image acquisition, image formation, image quality and display methods.  
3. Apply the concepts learnt in class to solve real-world problems in medical image reconstruction, image processing and analysis.  
4. Demonstrate an appreciation for the strengths and weaknesses of various imaging modalities and what kind of anatomical and physiological information can be obtained from them.

**Prerequisites:**  
1. University physics (PHYS 262 or equivalent).  
2. Familiarity with MATLAB  
3. Signals and Systems (BENG 320) or Discrete time signal processing (ECE 410)

**Resources:**  
**Course home page:**  
The course material distribution, assignments grading, announcements and discussion boards will be managed using BlackBoard. To access the course home page, log in using your email ID and password on [http://courses.gmu.edu](http://courses.gmu.edu). If you have difficulties using this system, please speak with the instructor and appropriate accommodations will be considered.
Required readings:

Textbook:

The lecture slides will be available through the course website. Additional reading and reference material wherever appropriate will be distributed to students periodically. Students are expected to read the assigned material prior to class.

Recommended references:

Course structure:

Grade:
Take-home exams: 25% x 4 = 100%
Bonus (attendance and class participation): 10%

Take-home Exams:
The exams will test the students’ understanding of key physics and imaging concepts as well as test their ability to analyze and interpret real imaging data, and perform relevant calculations. Many of these problems will involve some programming in MATLAB. Exams are to be submitted via Blackboard. Exams submitted late will NOT be accepted (exceptions will only be made for extenuating circumstances).

Class participation:
One student will be assigned each week on a rotating basis to take the lead on compiling a summary of the discussions in class and post it on the class home page. These summaries should be used as a supplement to the lecture slides in preparing for examinations and will contribute to the class participation grade. Students are expected to read the assigned material prior to class.
### Syllabus

<table>
<thead>
<tr>
<th>Wk</th>
<th>Date</th>
<th>Topics</th>
<th>Chapters</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>8/29/17</td>
<td>Introduction: what is medical imaging? Different imaging modalities.</td>
<td>1,2</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>9/5/17</td>
<td>Basic imaging concepts: point spread function, spatial and temporal resolution, contrast, filtering, interpolation, Fourier transforms. Image acquisition and reconstruction, resampling, manipulation, visualization; signal-to-noise; Patient safety.</td>
<td>2,3</td>
<td>Assign Exam 1</td>
</tr>
<tr>
<td>3</td>
<td>9/12/17</td>
<td>Principles of X-ray and nuclear imaging: radiation, attenuation, scattering, detection</td>
<td>4,5</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>9/19/17</td>
<td>Computed Tomography image reconstruction. Fourier slice theorem, filtered backprojection. 2D, 3D and 4D imaging.</td>
<td>6</td>
<td>Exam 1 due; Assign Exam 2</td>
</tr>
<tr>
<td>5</td>
<td>9/26/17</td>
<td>Nuclear imaging methods: positron emission tomography (PET), single photon emission computed tomography (SPECT); Optical imaging methods: near infrared spectroscopy (NIRS) and optical computed tomography (OCT)</td>
<td>7,8,9</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>10/03/17</td>
<td>Visit to INOVA (X-ray practicum)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>10/10/17</td>
<td>No class (Columbus day)</td>
<td></td>
<td>Exam 2 due</td>
</tr>
<tr>
<td>8</td>
<td>10/17/17</td>
<td>Principles of magnetic resonance imaging: spin physics</td>
<td>12</td>
<td>Assign Exam 3</td>
</tr>
<tr>
<td>9</td>
<td>10/24/17</td>
<td>MRI signal, data acquisition, image contrast. Image formation and k-space.</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>10/31/17</td>
<td>MRI imaging sequences</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>11/07/17</td>
<td>Principles of ultrasound imaging: acoustic waves, transmission, reflection, attenuation, Ultrasound transducers and instrumentation: steering, focusing, image formation.</td>
<td>10,11</td>
<td>Exam 3 due</td>
</tr>
<tr>
<td>12</td>
<td>11/14/17</td>
<td>Ultrasound signal and image processing. Imaging modes, A-mode, M-mode, B-mode, 2D, 3D and 4D imaging.</td>
<td>10,11</td>
<td>Assign Exam 4</td>
</tr>
<tr>
<td>13</td>
<td>11/21/17</td>
<td>New and emerging ultrasound technologies; BMIL tour and live demonstrations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>11/28/17</td>
<td>Introduction to medical image analysis: enhancement, manual and automated image analysis; segmentation; multimodality imaging, image registration, computer-aided detection. Course wrap up</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>12/05/17</td>
<td>No class</td>
<td></td>
<td>Exam 4 due</td>
</tr>
<tr>
<td>16</td>
<td>12/12/17</td>
<td>No Final Exam</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Academic Honesty and Collaboration:

The integrity of the University community is affected by the individual choices made by each of us. GMU has an Honor Code with clear guidelines regarding academic integrity. Three fundamental and rather simple principles to follow at all times are that: (1) all work submitted be your own; (2) when using the work or ideas of others, including fellow students, give full credit through accurate citations; and (3) if you are uncertain about the ground rules on a
particular assignment, ask for clarification. No grade is important enough to justify academic misconduct.

Take-home exams are designed to be undertaken independently. You may discuss your ideas with others and conference with peers; however, it is not appropriate to give your work to someone else to review. You are responsible for making certain that there is no question that the work you hand in is your own. If only your name appears on an assignment, your professor has the right to expect that you have done the work yourself, fully and independently.

Plagiarism means using the exact words, opinions, or factual information from another person without giving the person credit. Writers give credit through accepted documentation styles, such as parenthetical citation, footnotes, or endnotes. Paraphrased material must also be properly cited. A simple listing of books or articles is not sufficient. 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 see the instructor.

Relevant Campus and Academic Resources
Disability Services
Any student with documented learning disabilities or other conditions that may affect academic performance should: 1) make sure this documentation is on file with the Office of Disability Services (SUB I, Rm. 222; 993-2474; www.gmu.edu/student/drc) to determine the accommodations you might need; and 2) talk with the instructor to discuss reasonable accommodations.

Office of Diversity Programs and Services
SUB 1, Rm. 345; 993-2700; www.gmu.edu/student/msaf/index.html

Writing Center
Robinson A116; 993-1200; writingcenter.gmu.edu.

WAVES: Wellness, Alcohol and Violence Education and Services
WAVES promotes wellness within the Mason community through health education, alcohol/drug assessment and education, and violence awareness, prevention and sexual assault response. We help students make healthy, safe choices and encourage lifelong, thoughtful healthy decision-making through individualized support, creative programming, and evidence-based education and outreach.

WAVES office 703-993-9999
SUB I, Suite 3200

24-Hour Sexual and Intimate Partner Violence Crisis Line 703-380-1434
waves.gmu.edu

- 703-360-7273 (Fairfax County Office for Women and Domestic and Sexual Violence Services 25 hotline)
- 703- 228-4848 (Arlington County Domestic Violence Services Hotline)
- 703-368-4141 (Prince William County Sexual Assault Victims Advocacy Services (SAVAS) hotline)
- 1-800-838-8238 (Virginia Family Violence and Sexual Assault Hotline)
- 1-800-656-HOPE (Rape, Abuse and Incest National Network)
https://ohl.rainn.org/online/
**CAPS: Counseling and Psychological Services**

Counseling and Psychological Services (CAPS) provides a wide range of free *confidential* services to students, faculty, and staff. Services are provided by a staff of professional clinical psychologists, social workers, counselors, learning specialists, and psychiatric providers. CAPS individual and group counseling, workshops, and outreach programs are designed to enhance students’ personal experience and academic performance. Visit us at caps.gmu.edu for additional resources.

- For consultation or emergency assistance during office hours call 703-993-2380.
- For assistance during non-office hours, call University Police at 703-993-4357.
- 703-527-4077 (CrisisLink)
- 1-800-273-8255 (National Suicide Prevention Lifeline)
- 1-877-838-2838 (Veterans’ Crisis Hotline)

**Student Health Services (SHS)** — Provides *confidential* health care to enrolled students in emergency and non-emergency circumstances on the Fairfax, Arlington and Prince William campuses. If there is a medical emergency and Student Health Services (SHS) is closed, please contact the free after-hours nurse ((703) 993-2831), a hospital emergency room, an urgent care facility, or call 911.

**SUB 1, Suite 2300**

**703-993-2831**

**University Police:**

Emergency: 911 Non-Emergency: (703) 993-2810

Reporting a Crime (Crime Solvers Anonymous Tip Hot-Line): (703) 993-4111

Mason Police Website: http://police.gmu.edu/

Eric Heath, Chief of Police Phone: (703) 993-3840 E-mail: eheath2@gmu.edu