AMERICAN UNIVERSITY OF BEIRUT

FACULTY OF [Engineering and Architecture]
DEPARTMENT OF [Biomedical Engineering]
[Spring – 2024-25]
COURSE SYLLABUS

I. GENERAL COURSE INFORMATION

Course Number	BMEN 605
Course Title	Biomedical Imaging
Number of Credits	3
Course Level	Graduate
Course Format	Face-to-face, online, computer labs
Pre-requisite Courses	MATH 201 + instructor approval
Required/Elective	Elective
Meeting Schedule	MW 2-3:15 pm
Meeting Location	TBA

II. COURSE COORDINATOR, INSTRUCTORS AND TEACHING ASSISTANTS

Name	Role *(Instructor, Coordinator, TA,)*	Office Location	Office Hours	Extension	E-mail
Jason Amatoury	Course Coordinator and Instructor	Masri 407	TBA	3497	jason.amatoury@aub.edu.lb

III. COURSE DESCRIPTION

Biomedical imaging offers an unprecedented view into the structure and function of a living body, and as such plays an essential role in medical practice and research. This course will provide students with an overview of the key concepts underlying the primary diagnostic biomedical imaging modalities, including ultrasound, x-ray, computed tomography and magnetic resonance imaging. Students will gain an understanding of the physical principles and theoretical bases governing the operation of each imaging modality, the technology that translates theory into practice, and the basic methods involved in image formation. Students will also learn the limitations of each imaging procedure, while being exposed to their applications in the clinic and research. Additionally, students will acquire practical skills in processing biomedical images. They will also be introduced to fundamental concepts of machine learning and artificial intelligence (AI) and gain essential skills in applying them to medical images for image identification and disease detection.

IV. COURSE LEARNING OUTCOMES

Upon completion of the course, students will be able to:

- CLO1. Describe the fundamental principles governing the operation of common imaging modalities
- CLO2. Demonstrate an understanding of the concepts and methods in image acquisition and reconstruction
- CLO3. Explain the basic engineering and technology underlying each imaging modality

- CLO4. Critique each image modality in terms of advantages and disadvantages, limitations, and safety considerations
- CLO5. Explain and evaluate the influences of image quality for each modality
- CLO6. Describe clinical and research applications of each imaging modality
- CLO7. Understand fundamental principles of machine learning and AI as applied to biomedical imaging.
- CLO8. Acquire basic proficiency in preprocessing and analyzing imaging datasets.
- CLO9. Develop skills in implementing and evaluating machine learning and AI models for medical image classification.

V. PROGRAM LEARNING OUTCOMES ADDRESSED IN THE COURSE

1. Basic knowledge in engineering and biomedical sciences necessary to conduct research in biomedical engineering.
2. Advanced knowledge in various subareas related to biomedical engineering.
3. Ability to use techniques, skills, and tools useful for biomedical project design, experimental studies, and/or engineering practice.
4. Ability to pursue independent research utilizing interdisciplinary knowledge from various fields and generate novel contributions in biomedical engineering.
5. Understanding of the global impact of emerging new scientific findings in biomedical engineering.
6. Ability to communicate research findings effectively, in both oral and written formats, through presentations and reports including presentations at technical meetings and peer-reviewed publications.
7. Teamwork and life-long learning skills.

VI. COURSE RESOURCES AND REFERENCES

- Class notes and other selected material will be made available via Moodle
- There is no required textbook for the course, though the below will be regularly referenced and serve as great references (available via AUB library):
  - Bushberg, Jerrold T., and John M. Boone. The essential physics of medical imaging, 3rd ed., Lippincott Williams & Wilkins, 2011.
  - Suetens, Paul. Fundamentals of medical imaging, 2nd ed., Cambridge University Press, 2009.
  - Prince JL and Link JM. Medical imaging signals and systems, 2nd ed., Pearson, 2015.
  - McRobbie et al, MRI: From Picture to Proton, 3rd ed., Cambridge University Press, 2017

VII. COURSE OUTLINE

Note that for each imaging modality, we will essentially cover 1) physics, 2) image formation, 3) technology and 4) applications.

Week	Date	Topic*	Learning Activities** and Due Dates	Alignment with CLOs
1	S1-2	**Introductory Session. Introduction to biomedical imaging.**	Class, online sessions, activities.	CLO1-6
2	S3-4	**Image Quality.** **Ultrasound 1:** Fundamentals	Class and online sessions.	CLO1-6

Week	Date	Topic*	Learning Activities** and Due Dates	Alignment with CLOs
3	S5-6	**Ultrasound 2:** Ultrasound generation, beams and pulses. **Ultrasound 3:** Pulses, resolution, transducers.	Class and online sessions.	CLO1-6
4	S7-8	**Ultrasound 4:** Image acquisition and image quality. **Ultrasound 5:** Doppler and safety.	Class and online sessions.	CLO1-6
5	S9-10	**Ultrasound 6:** Applications and demo. **X-ray 1:** Fundamentals	Class sessions and demonstrations.	CLO1-6
6	S11-12	**X-ray 2:** The imaging system **X-ray 3:** Image formation	Class sessions and group activities.	CLO1-6
7	S13-14	**CT Imaging 1:** Fundamentals **CT Imaging 2:** Applications and contrast media	Class sessions. Guest speaker	CLO1-6
8	S15-16	**CT Imaging 3:** Dosage and clinical applications **MRI 1:** Fundamentals (NMR physics)	Class sessions. Guest speaker	CLO1-6
9	S17-18	**MRI 2:** RF Excitation, spin echoes, MRI contrast basics **MRI 3:** Data acquisition and image formation	Class sessions and activities	CLO1-6
10	S19-20	**MRI 4:** Image formation II (pulse sequences) **MRI 5:** Image Quality and Artifacts	Class sessions and activities	CLO1-6
11	S21-22	**MRI 6:** Hardware, safety and health effects **MRI 7:** Applications **Imaging Facility Tour.**	Class sessions and activities. Guest Speaker	CLO1-6
12	S23-24	**AI in Biomedical Imaging 1:** Introduction to machine learning and AI in biomedical imaging **AI in Biomedical Imaging 2:** Image preprocessing and enhancement	Class sessions, demonstrations, computer lab.	CLO1-9
13	S25-26	**AI in Biomedical Imaging 3:** Image segmentation and feature extraction **AI in Biomedical Imaging 4:** Machine learning model training	Class sessions, demonstrations, computer lab.	CLO1-9
14	S27-28	**AI in Biomedical Imaging 5:** Model evaluation and performance metrics **AI in Biomedical Imaging 6:** Projects and AI applications	Class sessions, demonstrations, computer lab.	CLO1-9

**Topics and their order may change during the semester*

VIII. COURSE EVALUATION/GRADING CRITERIA*

Type of Evaluation	Course LOs	Percentage
Major Assignment	CLO1-6	35%
Other Assignments	CLO1-9	45%
Turning the Table (TTT) (flipped classroom assessment)	CLO1-6	15%
Class Participation		5%
Total		**100%**

**subject to change*

IX. COURSE POLICIES

- **Attendance**
  Attendance at all sessions is required. However, if an absence is unavoidable, make sure to provide your instructor with the appropriate documentation (e.g. doctor's note).

- **Credit Hour Policy**
  This course follows AUB Credit Hour Policy for three-credit courses. This course meets twice weekly for 2.5 academic hours per week. Please refer to AUB Credit Hour policy and Credit Hour Assignment policy.

- **Submissions and Due Dates**
  Written assignments should be submitted on or prior to the due date. If you have an emergency or other extenuating circumstances and need to turn in an assignment later than its due date, you must contact the instructor before the assignment is due (by email).

- **Late Assignments**
  Please note that late submissions, without prior approval by your instructor, will be deducted 7.5% per day from the total assignment grade for each day the assignment is late (e.g. original grade = 85%, penalized grade for 1 day late = 77.5%). Assignments will not be accepted after more than 5 days from the original due date.

- **Group Work**
  Individuals must contribute their fair share to any group effort resulting in a deliverable to the instructor. In addition, everyone in the group will be held accountable for the quality, originality and proper sourcing of the entire group product.

- **Teaching Strategies and Technology Tools**
  Students will be expected to use several digital technologies throughout the course, including MS office, Web browsers, Moodle, Turnitin, image processing software and other relevant technologies.

- **Use of AI in the Course**
  The use of AI to generate original content is strictly prohibited. Students may use AI tools to help learn from and improve their original English writing and grammar in written assignments.

X. UNIVERSITY RULES AND REGULATIONS

- **General Academic Information**
  - Undergraduate Academic Information
  - Graduate Academic Information

- **University - Course Withdrawal Policy**

A student can withdraw from only one required course per semester. Students who wish to withdraw from more than one required course in any given semester must petition the appropriate faculty committee for permission to do so.

Check Withdrawal Information from undergraduate and graduate catalogue.

- **Academic Integrity (cheating and plagiarism):**

Please refer to AUB Student Code of Conduct, in particular section 1.1, which concerns academic misconduct including cheating, plagiarism, in-class disruption, and dishonesty. Please be aware that misconduct is vigorously prosecuted and that AUB has a zero tolerance policy. Course policy is that credible evidence of cheating will result in course failure.

- **Accessibility Statement to Acknowledge the Unique Learning Needs of Students with Disabilities:**

AUB strives to make learning experiences as accessible as possible. If you anticipate or experience academic barriers due to a diagnosed disability (including learning disability, mental health, chronic or temporary medical conditions), please contact the Accessible Education Office as soon as possible in order to help establish reasonable accommodations and facilitate a smooth learning process: accessibility@aub.edu.lb; +961-1-350000, x3151; West Hall, 338.

- **Non-Discrimination and Title IX Statement**

In line with its commitment to the principle of equal opportunity in education and employment, AUB policies protect you from discrimination on the basis of protected characteristics, including discriminatory harassment and sexual harassment. Protected characteristics include: race, color, religion, age, national or ethnic identity, sex, gender or gender identity, sexual orientation, pregnancy, marital status, disability, genetic predisposition or carrier status, alienage or citizenship status, and political affiliation.

The policies are applicable to all the AUB Community including: officers, faculty, staff, academic appointees, students (including medical interns and residents), visiting students, alumni, trainees, visitors, contractors, subcontractors, suppliers, located on campus and at AUB Medical Center, Advancing Research Enabling Communities Center (AREC), or any other facility or program affiliated with the University. The “AUB community” also includes the dependents and domestic employees of faculty and staff dwelling on campus and at AREC.

If you think you have experienced discrimination, discriminatory harassment, or sexual harassment, we encourage you to inform the Equity/Title IX Coordinator, Mitra Tauk at 01-350000 ext. 2514, titleix@aub.edu.lb, report to a Title IX deputy at your faculty or at any other faculty (www.aub.edu.lb/titleix), or report online (www.aub.ethicspoint.com). Reports may be submitted anonymously or not. Please know that the University will maintain the confidentiality of the complaint and privacy of the persons involved to the greatest extent possible, consistent with its goal of conducting a thorough and complete investigation and to the extent permitted by law.

You need to also know that the University has designated academic and administrative department/unit heads, managerial level staff, academic advisors, protection officers, and residence hall staff/monitors, as responsible employees or “mandatory reporters”, and may designate others at its discretion. These individuals are obligated to report actual or suspected discrimination or discriminatory harassing conduct to the Equity/Title IX Coordinator, unless they are a “confidential” resource. The following have been designated as confidential resources: on campus counselors in the Counseling Center of the Office of Student Affairs and AUB Medical Center counselors, and healthcare providers at the University Health Services (UHS) and at the AUB Medical Center. Confidential resources are not required to report actual or suspected discrimination or harassment to appropriate university officials, except in cases of suspected abuse of a minor, in the event of an external investigation or prosecution, or in the event of imminent danger to the reporting party or others.

XI. AUB GRADING SYSTEM

https://www.aub.edu.lb/Registrar/Pages/academic-information.aspx

Numeric Course Grade to Letter Course Grade

Starting with Numeric Course Grade /100	Corresponding Course Letter Grade
< 60	F
60	D
61–62	D+
63–65	C–
66–68	C
69–71	C+
72–74	B–
75–78	B
79–82	B+
83–86	A–
87–92	A
93–100	A+

Grade Conversion Chart

Course Letter Grade	Quality Points
A+	4.3
A	4.0
A–	3.7
B+	3.3
B	3.0
B–	2.7
C+	2.3
C	2.0
C–	1.7
D+	1.3
D	1.0
F	0.0

Note: The GPA at AUB is capped at 4.0

I	P	PR	W	NP
Incomplete	Pass	In Progress	Withdraw	No Pass