PURDUE UNIVERSITY | College of Engineering

Engineering Faculty Document
No.: 102-23
2/27/2023

TO: The Engineering Faculty

FROM: The Faculty of the Weldon School of Biomedical Engineering

RE: New 500-level course – BME 53000, Imaging Diagnostic Technologies for Medical and Biological Applications

The Faculty of the Weldon School of Biomedical Engineering has approved the following new 500-level course. This action is now submitted to the Engineering Faculty with a recommendation for approval.

FROM:

BME 59500 Medical Imaging & Diagnostic Technologies
Term offered: Fall
3 credit Lecture
Requisites, Restrictions, and Attributes: None
Previously offered both on-campus and on-line; Fall 2018 (10 enrolled), Fall 2019 (8 in-class + 9 online), Fall 2020 (9 in-class + 6 online) Fall 2021 (37 in-class + 5 online), Fall 2022 (20 in-class + 8 online).

TO:

BME 53000 Imaging Diagnostic Technologies for Medical and Biological Applications
Term offered: Fall
3 credit Lecture
Requisites, Restrictions, and Attributes: None

Description:

This gateway course teaches the physics, engineering techniques associated with modern imaging and diagnostic tools for biological and medical applications. The course covers fundamental principles of radiology, optics, contrast generation (including genetically encoded probes and physiological indicators), image formation, detection, and analysis. The specific biomedical imaging modalities covered include: x-ray, computed tomography, nuclear medicine imaging, ultrasound, optical microscopy and tomography, and MRI. The specific biological microscopy modalities covered include: phase contrast, DIC, confocal microscopy, two-photon microscopy and super-resolution microscopy. The course also teaches the principle concepts of adaptive optics, lightsheet microscopy, 4Pi microscopy, and modern super-resolution microscopy techniques (PALM/STORM, STED and ISM). To bridge the technology and physics with the latest diagnostic advances and biomedical discoveries, research progresses in specific biomedical applications are presented by leading experts in their respective biomedical field such as OCT, ultrasound, MRI, fluorescence microscopy, electron microscopy, concurrent MRI and optical functional imaging, and super-resolution

fluorescence microscopy. This course also includes a crash sub-course on MATLAB programming including both introductory content and contents of MATLAB-C API and MATLAB-C-CUDA (GPU computing).

RATIONALE:

This graduate level course teaches the physics & engineering techniques associated with modern imaging and diagnostic tools for biological and medical applications.
This gateway course is part of the gateway requirement for the Imaging Area of Excellence in the BME graduate programs and also serves as a core BME course for engineering professional students in the online BME concentration through Purdue Engineering Online. It has been offered 5 times previously and course evaluation scores have all been above 4.0.

David M. Umulis
Dane A. Miller Head and Professor
Weldon School of Biomedical Engineering

Link to Curriculog entry: BME - 53000 - Imaging Diagnostic Technologies for Medical and Biological Applications | Curriculog

BME 53000 Imaging Diagnostic Technologies for Medical and Biological Applications

Dr. Fang Huang
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Phone: 765-494-6216
Email: huang892@purdue.edu
Office Hours: Friday 9:30 am – 10:30 am, online and in office
Zoom (office hour): https://purdue-edu.zoom.us/j/98936867769

Course Information

MWF 8:30-9:20
MJIS 1083

Course Description

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Guest Lectures (GL)

These lectures cover aspects that are not covered during normal lectures of the course from leading labs in various field at Purdue which include: microscopy application in cell biology (Suter, Prof. in Biology), electron microscopy and applications (Jiang, Prof. in Biology), concurrent MRI and optical functional Imaging (Tong, Prof. in BME), MRI (Rispoli, Prof. in BME) and super-resolution microscopy (Huang, Prof. in BME).

Learning Objectives:

1. Describe fundamental principles, such as atomic structure, particle and tissue interactions, light and sound propagation, Huygens' principle, refraction, interference, diffraction and abbe's fundamental resolution limit, wave propagation of light and sound, Fresnel and Fraunhofer diffraction principles.

2. Describe the general concept of signal detection, principles of detectors, noise sources and leading development trend of detectors such as APD, PMT, CCD, CMOS, EMCCD and sCMOS.
3. Describe physical principles and considerations of instrumentation design in planar radiography, fluoroscopy, computed tomography (CT), positron emission tomography (PET), single photon emission computed tomography, ultrasound imaging and magnetic resonance imaging.
4. Understand, design and draw basic optical sketches for a simplified imaging system in either wide-field, or focused optical geometry. These imaging systems includes: Widefield, Phase Contrast, DIC, Confocal, Two photon, Adaptive optics (AO) two photon, 4Pi, I5M, SIM, RESOLFT, STED and PALM/STORM microscopy techniques.

Weekly quizzes including open questions on the taught principles and concepts will be used to assess learning and retention.

Learning Activities:

1. Lectures
2. Practice problems
3. Assigned reading and handouts
4. Online java applet
5. In-class brainstorm sessions and discussions
6. Journal article report
7. Presentation

Course Schedule:

Week#	General content target	Activities	Quiz
1	Overview of imaging, physics, radiation in common		
2	Principle of planar radiography, instrumentation and its applications. Principle of CT, instrumentation and applications.		Quiz1
3	CT instrumentation and reconstruction		Quiz2
4	SPECT and PET, instrumentation and application,	GL1 (Schaber)	Quiz3
5	Ultra-sound principle, instrumentation and applications		Quiz4
6	Introduction to MATLAB, variables, functions, structure and regression. Common detectors in Biomedical applications: APD, PMT, CCD, EMCCD and CMOS.		Quiz5
7	Detectors (continue). Optical microscopy principle, physics and instrumentation, contrast generation in cell and tissue samples.		Quiz6
8	Widefield, confocal microscopy, Tissue imaging		Quiz7
9	Two photon microscopy and principle adaptive optics		Quiz8
10	Functional imaging and applications	GL2 (Suter)	Quiz9
11	Light-sheet microscopy and CARS. Super-resolution microscopy: SIM and STED		Quiz10
12	Super-resolution microscopy: PALM/STORM, Principles of MRI	GL3 (Jiang)	Quiz11
13	MRI physics and imaging techniques	GL4 (Tong)	Quiz12
14	MRI application, fMRI and developments	GL5 (Rispoli)	Quiz13
15	Student presentation on final projects (groups)	Presentations	Quiz14

Prerequisites (if needed)

None

Course Requirements

Homework: There's no homework in this course.

Quizzes: Weekly quizzes, each consisting of 3-5 open questions on the taught physics principles, engineering concepts and system design diagrams will be given throughout the semester. The quizzes will be held on Wednesday session during the class in which the quiz is administered and the topic to be quizzed will be related to what has been taught during the last 2-3 lectures. They will also be used to assess the retention, and the understanding and integration of the course material from the previous lectures. A total of 14 quizzes will be given. Considering the extended range of imaging concepts taught in the class and the diverse backgrounds of the attending students, part of the final grade of an individual student will be based on his/her best 10 scores out of the 14 quizzes.

For online students, the quiz will be made available on blackboard with the instruction on Wednesdays. After finishing the quiz, please scan (or take a picture) and send your completed quiz as a pdf file to fanghuang@purdue.edu before the end of Thursday of the same week.

Final project: A final project will require the student to apply knowledges and skills obtained in the course to investigate an area covered in the course. These projects will be completed in self-selected teams of 2 to 3 students consisting of diverse/different training background over the last month of the course. Working as a group with a diverse knowledge base, the team will perform a formal presentation of the findings of a selected journal article during the final week(s) of lectures. The final written project reports will be evaluated by the instructor for clarity, logical progression, in-depth understanding, correctness and significance of findings, in such order.

Required Texts

1. "**Introduction to Biomedical Imaging**", Andrew G. Webb, 1st Edition, Wiley-IEEE Press, 2002
2. "**Fundamentals of Light Microscopy and Electronic Imaging, 2nd Edition**" by Douglas B. Murphy and Michael W. Davidson, Wiley-Blackwell 2013

Additional recommended text

3. "**The Essential Physics of Medical Imaging, Third Edition**" by Jerrold T. Bushberg, ISBN-13: 978-0781780575

Students are expected to learn from courseware including handouts, online java applet (http://micro.magnet.fsu.edu/).

Policies

General Course Policies

Questions from Students should be directed to the instructor. Due to the nature of the short quizzes given in the beginning of each lecture (15 mins), no makeup quizzes will be provided. Cell phones and computers should be put in silence mode during the instruction. This course expects students to fully engage with questions and discussions during the class with the instructor.

Grading:

Quizzes*:	60%
Final project (presentation):	20%
Final project (report):	20%
Total	**100%**

Grade Scale: The following grading scale is just for your reference. Based upon ensemble class performance, final grades will be curved up by the instructor *if appropriate*. Students are welcome to discuss his/her progress with the instructor throughout the semester.

>95%	A+
90-94.9%	A
87-89.9%	A-
85-86.9%	B+
80-84.9%	B
78-79.9%	B-
75-77.9%	C+
70-74.9%	C
65-69.9%	C-
60-64.9%	D
<60	F

*To calculate the grade for quizzes, the best 10 scores out of a total 14 quizzes for each student will be used.

Academic Dishonesty
Purdue prohibits "dishonesty in connection with any University activity. Cheating, plagiarism, or knowingly furnishing false information to the University are examples of dishonesty." [Part 5, Section III-B-2-a, University Regulations] Furthermore, the University Senate has stipulated that "the commitment of acts of cheating, lying, and deceit in any of their diverse forms (such as the use of substitutes for taking examinations, the use of illegal cribs, plagiarism, and copying during examinations) is dishonest and must not be tolerated. Moreover, knowingly to aid and abet, directly or indirectly, other parties in committing dishonest acts is in itself dishonest." [University Senate Document 72-18, December 15, 1972]

If the instructor concludes that the student has committed academic dishonesty, the matter may be resolved with the student through punitive grading. Examples of punitive grading are giving a lower or failing grade on the assignment, having the student repeat the assignment and perhaps some additional assignment, or assessing a lower or failing grade for the course. The grade appeals system offers recourse to a student whose grade has been reduced unfairly for alleged academic dishonesty.

Academic Guidance in the Event a Student is Quarantined/Isolated
If you become quarantined or isolated at any point in time during the semester, in addition to support from the Protect Purdue Health Center, you will also have access to an Academic Case Manager who can provide you academic support during this time. Your Academic Case Manager can be reached at acmq@purdue.edu and will provide you with general guidelines/resources around communicating with your instructors, be available for academic support, and offer suggestions for how to be successful when

learning remotely. Importantly, if you find yourself too sick to progress in the course, notify your academic case manager and notify me via email or Brightspace. We will make arrangements based on your particular situation. The Office of the Dean of Students (odos@purdue.edu) is also available to support you should this situation occur.

Attendance
Students should stay home and contact the Protect Purdue Health Center (496-INFO) if they feel ill, have any symptoms associated with COVID-19, or suspect they have been exposed to the virus. In the current context of COVID-19, in-person attendance will not be a factor in the final grades, but the student still needs to inform the instructor of any conflict that can be anticipated and will affect the submission of an assignment or the ability to take an exam. Only the instructor can excuse a student from a course requirement or responsibility. When conflicts can be anticipated, such as for many University-sponsored activities and religious observations, the student should inform the instructor of the situation as far in advance as possible. For unanticipated or emergency conflict, when advance notification to an instructor is not possible, the student should contact the instructor as soon as possible by email, through Brightspace, or by phone. When the student is unable to make direct contact with the instructor and is unable to leave word with the instructor's department because of circumstances beyond the student's control, and in cases of bereavement, quarantine, or isolation, the student or the student's representative should contact the Office of the Dean of Students via email or phone at 765-494-1747. Our course Brightspace includes a link on Attendance and Grief Absence policies under the University Policies menu.

Classroom Guidance Regarding Protect Purdue
The Protect Purdue Plan, which includes the Protect Purdue Pledge, is campus policy and as such all members of the Purdue community must comply with the required health and safety guidelines. Required behaviors in this class include: staying home and contacting the Protect Purdue Health Center (496-INFO) if you feel ill or know you have been exposed to the virus, properly wearing a mask in classrooms and campus building, at all times (e.g., mask covers nose and mouth, no eating/drinking in the classroom), disinfecting desk/workspace prior to and after use, maintaining appropriate social distancing with peers and instructors (including when entering/exiting classrooms), refraining from moving furniture, avoiding shared use of personal items, maintaining robust hygiene (e.g., handwashing, disposal of tissues) prior to, during and after class, and following all safety directions from the instructor.

Students who are not engaging in these behaviors (e.g., wearing a mask) will be offered the opportunity to comply. If non-compliance continues, possible results include instructors asking the student to leave class and instructors dismissing the whole class. Students who do not comply with the required health behaviors are violating the University Code of Conduct and will be reported to the Dean of Students Office with sanctions ranging from educational requirements to dismissal from the university.

Any student who has substantial reason to believe that another person in a campus room (e.g., classroom) is threatening the safety of others by not complying (e.g., not wearing a mask) may leave the room without consequence. The student is encouraged to report the behavior to and discuss next steps with their instructor. Students also have the option of reporting the behavior to the Office of the Student Rights and Responsibilities. See also Purdue University Bill of Student Rights.

Grief Absence Policy for Students
Purdue University recognizes that a time of bereavement is very difficult for a student. The University therefore provides the following rights to students facing the loss of a family member through the Grief Absence Policy for Students (GAPS). GAPS Policy: Students will be excused for funeral leave and given the opportunity to earn equivalent credit and to demonstrate evidence of meeting the learning outcomes for missed assignments or assessments in the event of the death of a member of the student's family.

Missed or Late Work
No make-up homework and quizzes will be accepted unless specific situation are made clear to Dr. Huang prior or shortly after the date of quiz.

Regrade Policy: Students have the right to contest any grades throughout the semester. In the event that a student feels a quiz has been inappropriately graded, the student must provide a clear explanation for the regrading submission along with the original quiz. Students have **1 week** after the return of a graded work to protest a grade; after this time grade disputes will not be accepted.

Violent Behavior Policy
Purdue University is committed to providing a safe and secure campus environment for members of the university community. Purdue strives to create an educational environment for students and a work environment for employees that promote educational and career goals. Violent Behavior impedes such goals. Therefore, Violent Behavior is prohibited in or on any University Facility or while participating in any university activity.

Students with Disabilities
Purdue University is required to respond to the needs of the students with disabilities as outlined in both the Rehabilitation Act of 1973 and the Americans with Disabilities Act of 1990 through the provision of auxiliary aids and services that allow a student with a disability to fully access and participate in the programs, services, and activities at Purdue University.

If you have a disability that requires special academic accommodation, please make an appointment to speak with me within the first three (3) weeks of the semester in order to discuss any adjustments. It is important that we talk about this at the

beginning of the semester. It is the student's responsibility to notify the Disability Resource Center (http://www.purdue.edu/drc) of an impairment/condition that may require accommodations and/or classroom modifications.

Emergencies

In the event of a major campus emergency, course requirements, deadlines and grading percentages are subject to changes that may be necessitated by a revised semester calendar or other circumstances beyond the instructor's control. Relevant changes to this course will be posted onto the course website or can be obtained by contacting the instructors or TAs via email or phone. You are expected to read your @purdue.edu email on a frequent basis.

Nondiscrimination

Purdue University is committed to maintaining a community which recognizes and values the inherent worth and dignity of every person; fosters tolerance, sensitivity, understanding, and mutual respect among its members; and encourages each individual to strive to reach his or her own potential. In pursuit of its goal of academic excellence, the University seeks to develop and nurture diversity. The University believes that diversity among its many members strengthens the institution, stimulates creativity, promotes the exchange of ideas, and enriches campus life.

Purdue University prohibits discrimination against any member of the University community on the basis of race, religion, color, sex, age, national origin or ancestry, genetic information, marital status, parental status, sexual orientation, gender identity and expression, disability, or status as a veteran. The University will conduct its programs, services and activities consistent with applicable federal, state and local laws, regulations and orders and in conformance with the procedures and limitations as set forth in Executive Memorandum No. D-1, which provides specific contractual rights and remedies. Any student who believes they have been discriminated against may visit www.purdue.edu/report-hate to submit a complaint to the Office of Institutional Equity. Information may be reported anonymously.