

Academic Year: (2023 / 2024)

Review date: 19-12-2023

Department assigned to the subject: Bioengineering Department

Coordinating teacher: RIPOLL LORENZO, JORGE

Type: Electives ECTS Credits : 6.0

Year : 4 Semester :

REQUIREMENTS (SUBJECTS THAT ARE ASSUMED TO BE KNOWN)

It is strongly advised to have completed Physics I and II. It is also very beneficial, but not compulsory, if Differential equations and Numerical Methods in Biomedicine have been completed. No prior knowledge on optics or image formation is required.

SKILLS AND LEARNING OUTCOMES

RA3: Be able to carry out conceptual designs for bioengineering applications according to their level of knowledge and understanding, working in a team. Design encompasses devices, processes, protocols, strategies, objects and specifications broader than strictly technical, including social awareness, health and safety, environmental and commercial considerations.

RA4: Be able to use appropriate methods to carry out studies and solve problems in the biomedical field, commensurate with their level of knowledge. Research involves conducting literature searches, designing and carrying out experimental practices, interpreting data, selecting the best approach and communicating knowledge, ideas and solutions within their field of study. May require consultation of databases, safety standards and procedures.

RA5: Acquire intermediate/advanced knowledge of engineering and biomedical sciences and demonstrate an understanding of the theoretical and practical aspects and methodology of work in their field of study.

CB1: Students have demonstrated possession and understanding of knowledge in an area of study that builds on the foundation of general secondary education, and is usually at a level that, while relying on advanced textbooks, also includes some aspects that involve knowledge from the cutting edge of their field of study.

CB2: Students are able to apply their knowledge to their work or vocation in a professional manner and possess the competences usually demonstrated through the development and defence of arguments and problem solving within their field of study.

CB3: Students have the ability to gather and interpret relevant data (usually within their field of study) in order to make judgements which include reflection on relevant social, scientific or ethical issues.

CB4: Students should be able to communicate information, ideas, problems and solutions to both specialist and non-specialist audiences.

CB5: Students will have developed the learning skills necessary to undertake further study with a high degree of autonomy.

CG2: Ability to design, draft and develop scientific-technical projects in the field of biomedical engineering.

CG4: Ability to solve problems with initiative, decision-making, creativity, and to communicate and transmit knowledge, skills and abilities, understanding the ethical, social and professional responsibility of the biomedical engineer's activity. Capacity for leadership, innovation and entrepreneurial spirit.

CG6: Knowledge of current standards, regulations and legislation and ability to apply them to bioengineering projects. Bioethics applied to biomedical engineering.

CG7: Drafting, representing and interpreting scientific-technical documentation.

CG8: Ability to solve mathematical, physical, chemical and biochemical problems that may arise in biomedical engineering.

CG12: Ability to solve mathematically formulated problems applied to biology, physics and chemistry, using numerical algorithms and computational techniques.

CG19: Ability to apply different image analysis and processing techniques, as well as artificial vision to the resolution of problems of biological and medical interest. In particular, the problems of diagnosis by Medical Imaging stand out.

CG21: Ability to analyse complex and multidisciplinary problems from the global point of view of Biomedical Instrumentation.

CT1: Ability to communicate knowledge orally and in writing to both specialised and non-specialised

audiences.

CT2: Ability to establish good interpersonal communication and to work in multidisciplinary and international teams.

CT3: Ability to organise and plan their work, making the right decisions based on the information available, gathering and interpreting relevant data in order to make judgements within their area of study.

OBJECTIVES

The student that successfully finishes this course will have an advanced understanding of image formation and how contrast, resolution and signal to noise ratio affects image quality, the quantitative information it may deliver and its interpretation. These main aspects of imaging (resolution, contrast, and quantification) will be studied within different imaging modalities, either currently used in medical imaging or under development for their future implementation in the clinic. Once this course has been completed the student should be able to discuss and defend which imaging modalities are more appropriate for a specific instance, and why. In particular, it is expected that each student will have a good understanding of what each imaging approach can deliver in terms of sensitivity, resolution and quantitation; within the skills acquired the student should be able to second an imaging or combined set of imaging approaches for current medical imaging scenarios.

DESCRIPTION OF CONTENTS: PROGRAMME

1. Physical Principles of Image Acquisition and Formation. Sensors.
2. Resolution, Contrast and Noise in Image Formation
3. Current Laser Technology and Biomedical Applications
4. Interaction of Light with Cells and Tissues
5. Principles of Optical Microscopy and Spectroscopy
6. Functional Imaging: Ultrasound and Optics combined
7. Nonlinear Optical Imaging
8. Deep tissue imaging
9. Other Imaging Modalities and Imaging Displays

Transversal content: The structure of a business plan, the canvas and SWOT matrix. The structure of a research proposal. Matlab/Octave programming.

LEARNING ACTIVITIES AND METHODOLOGY

LECTURES:

Due to the large amount of topics covered and their multidisciplinary nature, it is strongly advised that the student reads the recommended chapters or sections before the class. These will be provided at least one week in advance.

- 1) Lectures: During the lectures the proposed topic will be presented, always encouraging discussion.
- 2) Discussion Sessions: When the topic allows it, discussion sessions will be held to solve particular problems related to the current topic with the main idea of understanding the system and developing different strategies to solve it, underlining the fact that there are almost always different approaches to the same problem.
- 3) Biomedical Project. In individual groups the students will develop the project for a technology based company for biomedical applications which makes use of biomedical imaging approaches.
- 4) Oral Presentations: At least once during the course each student will have the chance to do a short oral presentation on a topic related to the Biomedical Project chosen. These oral presentations will have a duration of approx. 10-20 minutes per student.

HOMEWORK:

Recommended research papers will have to be studied prior to each other's student oral presentation. Data analysis and representation for the laboratory sessions will need good skills in matlab/octave.

LABORATORY SESSIONS:

Each experiment will be performed in individual groups. During these sessions simple experiments will be done to understand the basics of light transport in tissues, and how scattering affects image quality in microscopy, with emphasis on 3D microscopy. The main goal during these sessions is to understand the physics behind the experiment and how it relates to the theory we presented during the lectures, to obtain rigorous experimental data, and to have a clear understanding on the basis of image formation. Different software for 3D data analysis will be used, mostly Matlab (or Octave) and ImageJ.

ASSESSMENT SYSTEM

The final grade will be a combination of Laboratory Sessions (20%), Continuous Assessment (40%) (note that 20%+40%=60%) and Final Exam (40%), in particular:

1) **LABORATORY SESSIONS (20%)**: Grades will be given for the effort, not for how accurate the final result is. What is important is demonstrate that a clear understanding of the technique used was achieved. The grade will be shared in case the experiment was done by more than one student.

2) **CONTINUOUS ASSESSMENT (40%)**: Within this category we will have grades for one mid-term exam (20%) and the Biomedical Project (20%) which includes an oral presentation of each student.

3) **FINAL EXAM (40%)**: The final exam will be a written exam and take place at the end of the course, being common for all students. It will include problems and multiple choice questions to be solved covering the main topics of the course. The **MINIMUM SCORE** in order for the result to count in the overall grade of the course is 4.0 over 10, irrespective of the grades obtained in the continuous evaluation.

EXTRAORDINARY EXAM

The continuous evaluation grade is maintained for the extraordinary exam. The final grade for the extraordinary exam will be the maximum between a 100% of the extraordinary exam and 60% continuous evaluation + 40% exam.

EXCHANGE STUDENTS ABROAD

Students following the course from abroad will thus miss all activities which require physical presence (experiments, biomedical project and oral presentation). In this case they will only have access to 60% of the grade after the final exam (60% final exam, and 20% mid term done via internet). In order to access 100% of the grade they will have to take the extraordinary exam at the end of the school year.

DISHONEST CONDUCT

Copying and otherwise dishonest conduct is not allowed in any the activities of this course and will be punished with severities which may range between a zero in that particular activity and a disciplinary hearing by the council of the university.

% end-of-term-examination:	40
% of continuous assessment (assignments, laboratory, practicals...):	60

BASIC BIBLIOGRAPHY

- David Boas, Constantinos Pitris and Nimmi Ramanujam Handbook of Biomedical Optics, CRC press, 2011
- Markus Rudin Molecular Imaging: Principles And Applications In Biomedical Research, Imperial College Press, 2005

ADDITIONAL BIBLIOGRAPHY

- Douglas B. Murphy and Michael W. Davidson Fundamentals of Light Microscopy and Electronic Imaging, Wiley-Blackwell, 2012
- Paras N. Prasad Introduction to Biophotonics, Wiley, 2003