Biomedical applications of nanotechnology

Academic Year: (2023 / 2024) **Review date: 26-01-2024**

Department assigned to the subject: Bioengineering Department

Coordinating teacher: MUÑOZ BARRUTIA, MARIA ARRATE

Type: Electives ECTS Credits : 6.0

Year : 4 Semester :

REQUIREMENTS (SUBJECTS THAT ARE ASSUMED TO BE KNOWN)

Students are strongly advised to have completed the subjects Chemistry, Materials Science and Engineering, Introduction to the design of medical instrumentation, Signals and systems and Introduction to Biomaterials.

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.
CG9: Ability to analyse and conceptually design electronic devices to solve problems in biology and medicine.
CG15: Ability to apply microfabrication, microfluidics, nanotechnology and 3D printing techniques in the field of biomaterials.
CG20: Ability to design instruments for medical applications, from surgical instruments to micro and

nanometric biosensors.
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 students will learn the basic principles of nanotechnology applied to biomedical problems in lectures and teamwork activities on reviewing articles and practices in the laboratory.

The course will focus on designing devices based on nanotechnologies and the preparation of nanoparticles. It will also address the clinical application of these technologies in diagnosis (including imaging) and therapy and their application in biomedicine.

Students will familiarize themselves with the main techniques for the synthesis, characterization, and biofunctionalization of the most common nanomaterials and their use in biometric devices or as contrast agents for diagnosis and therapy.

DESCRIPTION OF CONTENTS: PROGRAMME

1.- Introduction to nanotechnology
2.- Imaging and characterizing the nanoscale
3.- Nanosensors for clinical applications
4.- Imaging nanodevices
5.- Nanodevices for manipulation of cells and biomolecules
6.- Nanoparticles for drug and gene delivery
7.- Modification and functionalization of nanoparticles for diagnosis and therapy
8.- Safety and toxicity concerns of nanosystems

Lab practices
The dates will be announced early in the course.
Practices will cover the preparation of liposomes, synthesis of gold nanomaterials, gold nanoparticle-based sensors, design and characterization of nanotechnology-based sensors, and electronics for nanotechnology.

LEARNING ACTIVITIES AND METHODOLOGY

Each program section will be divided into lectures and practical sessions or seminars.

The teaching methodology is based on master classes that introduce the fundamental concepts, seminars in which examples are illustrated in detail, and practical sessions in the laboratory.

Students are required to read the assigned documentation before conferences and seminars. The lectures will be used to highlight and clarify some difficult or interesting points of the corresponding lesson. The seminars will be devoted mainly to interactive discussions with the students and conducting partial exams.

The tutoring regime will be published in Aula Global.

ASSESSMENT SYSTEM

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

Grading will be based on continuous evaluation and a final exam covering the whole subject, including invited lectures and seminars. Tutorship sessions and tutorial classes will be held prior to the final exam upon students' request. Failure to attend any test or submit the exercises before the deadline will result in a zero mark in the corresponding continuous evaluation block (see below).

GRADING:

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

Total score: 10 points
Continuous evaluation: 6 points out of 10
Final exam: 4 points out of 10

CONTINUOUS EVALUATION: It accounts for up to 60% of the final score of the subject (6 points of the total score), and includes two components:
1) Homework and midterm exams: Three points of the total score. Deadlines and test dates will be announced at least one week in advance.
2) Laboratory practices and exercises: Three points of the total score.

FINAL EXAM: The final exam will cover the whole subject, including invited lectures and seminars, and will account for 40 % of the final score (4 points of the total score). The minimum score in the final exam to pass the subject is 4 over 10, notwithstanding the mark obtained in continuous evaluation.

EXTRAORDINARY EXAM: The mark for students attending any extraordinary examination will be either
a) 100% extraordinary exam mark, or
b) 40% extraordinary exam mark and 60% continuous evaluation, if available in the same course, at the student's request.

ACADEMIC CONDUCT: Unless specified, all exams will be closed-book, closed-notes, no PC or mobile phone, or anything other than a writing implement and the exam itself. Plagiarism, cheating, or other acts of academic dishonesty will not be tolerated. Any infractions will result in a failing grade.

BASIC BIBLIOGRAPHY

- BS Murty, P Shankar, B Raj, BB Rath, J Murday Textbook of Nanocience and Nanotechnology, Springer University Press, 2013

- C. Sharma Drug Delivery Nanosystems for Biomedical Applications, Elsevier, 2014

ADDITIONAL BIBLIOGRAPHY

- A. Offenhäusser, R. Rinaldi (Editors) Nanobioelectronics - for Electronics, Biology and Medicine, Nanostructure Science and Technology Series, Springer, 2009

- A. P. Lee, L. James Lee (Editors) Biological and Biomedical Nanotechnology, Volume I, Biological and Biomedical Nanotechnology, Springer, 2006

- Kevin C. Honeychurch (Editor Nanosensors for Chemical and Biological Applications: Sensing with Nanotubes, Nanowires and Nanoparticles, Woodhead Publishing, 2014

- Mauro Ferrari, Ph.D., Editor-in-Chief. BioMEMS and Biomedical Nanotechnology. Vol. 1 Biological and Biomedical Nanotechnology, Springer, 2006

- Paras N Prasad Introduction to Nanomedicine and Nanobioengineering: Transforming Healthcare with Nanotechnology, John Wiley and Sons, 2012

- Rajaventhan Srirajaskanthan, M.D.,Victor R. Preedy, Ph.D Nanomedicine and Cancer, CRC Press, 2012

- Vijay K. Varadan,LinFeng Chen,Jining Xie Nanomedicine: Design and Applications of Magnetic Nanomaterials, Nanosensors , John Wiley and Sons, 2008

BASIC ELECTRONIC RESOURCES

- Georgia Tech . Nanohub: https://nanohub.org/