Biomedical applications of nanotechnology

Academic Year: (2024 / 2025) **Review date: 21-05-2024**

Department assigned to the subject: Bioengineering Department

Coordinating teacher: MUÑOZ BARRUTIA, MARIA ARRATE

Type: Electives ECTS Credits : 6.0

Year : Semester :

REQUIREMENTS (SUBJECTS THAT ARE ASSUMED TO BE KNOWN)

It is recommended to have passed the following courses:
- Materials science and engineering
- Instrumentation and measurements
- Nanoelectronics and Nanophotonics

SKILLS AND LEARNING OUTCOMES

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. Learn new methods and technologies from basic scientific and technical knowledge, and being able to adapt to new situations.
CG3. Solve problems with initiative, decision making, creativity, and communicate and transmit knowledge, skills and abilities, understanding the ethical, social and professional responsibility of the engineering activity. Capacity for leadership, innovation and entrepreneurial spirit.
CG4. Solve mathematical, physical, chemical, biological and technological problems that may arise within the framework of the applications of quantum technologies, nanotechnology, biology, micro- and nano-electronics and photonics in various fields of engineering.
CG5. Use the theoretical and practical knowledge acquired in the definition, approach and resolution of problems in the framework of the exercise of their profession.
CG6. Develop new products and services based on the use and exploitation of new technologies related to physical engineering.
CG7. Undertake further specialized studies, both in physics and in the various branches of engineering.
CE11. Analyze biological systems as complex systems, know the concepts of synthetic biology and apply the latest developments in biomaterials and biofabrication techniques, including bioprinting techniques.
CT1. Work in multidisciplinary and international teams as well as organize and plan work making the right decisions based on available information, gathering and interpreting relevant data to make judgments and critical thinking within the area of study.

RA1. To have acquired sufficient knowledge and proved a sufficiently deep comprehension of the basic principles, both theoretical and practical, and methodology of the more important fields in science and technology as to be able to work successfully in them.
RA2. To be able, using arguments, strategies and procedures developed by themselves, to apply their knowledge and abilities to the successful solution of complex technological problems that require creating and innovative thinking.

RA3. To be able to search for, collect and interpret relevant information and data to back up their conclusions including, whenever needed, the consideration of any social, scientific and ethical aspects relevant in their field of study.
RA4. To be able to successfully manage themselves in the complex situations that might arise in their academic or professional fields of study and that might require the development of novel approaches or solutions.
RA6. To be aware of their own shortcomings and formative needs in their field of specialty, and to be able to plan and organize their own training with a high degree of independence.

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 nanoparticles-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:	60
% of continuous assessment (assigments, laboratory, practicals…):	40

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:
Total score: 10 points
Continuous evaluation: 6 points out of 10

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

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 (Editors) 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

- 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/