Teaching Programme:

Biosensors and Nanotechnology

This Teaching Programme corresponds to one of the optional subjects of the Degree on Biomedical Engineering. Since this subject is taught in the last year of this Degree program, actually in the 7th semester, the present syllabus corresponds to a descriptive subject, where the students will know the state of the art of the sensing techniques applied in the biomedical field. Once the students complete this subject, they will learn the most common magnitudes and figures of merit used to characterize sensors. Moreover, they will know the most usual technologies employed in biomedical applications. Finally, in addition to this, they will be shown the main techniques for micro and nanofabrication of biomedical sensing, together with the standard procedures and instrumentation employed in applied research laboratories devoted to sensing.

As mentioned, this programme correspond to an optional subject. Thanks to this freedom, it will be directly linked with the research profile of the required researcher, so that the students will benefit from his/her expertise and research activity. In particular, this subject covers the basics of the research line addressed in the Research Project, since it includes training on the most common sensing configurations. Moreover, it also includes micro and nano-technology fundamentals, which also correspond to the required expertise of the required researcher.

Therefore, this teaching programme is directly linked with the research activity carried out in Campus Iberus' Multimodal Diagnosis research line, which belongs to the Health Technologies area. It will allow training the students in a set of sensing technologies that find direct application in this area. This way, the students' instruction in this field gets completed, which allows a direct contribution to the Campus Iberus' objectives in the area of Health Technologies.

At the same time, these students will benefit from the high level research to be carried out in a close topic such as that proposed in this project. Thanks to the high level training that they will achieve they will be ideal candidates to continue their studies in this field, by doing their Final Year Projects or engaging the master in Biomedical Engineering, or alternatively to start their career in companies working in this area, which will help transferring to industry the result of the research carried out.

1. Module / Subject matter

Optional module. 7th semester.

2. Descriptors

Biomolecules; Biosensor; Biomedical engineering; Instrumentation; Applied research; Nanotechnology; Sensors

3. Generic competences

This subject contributes to the following generic competences, as defined in the description of the Degree on Biomedical Engineering of the Public University of Navarra:

CB2 - Ability to apply the acquired knowledge in a professional way and capacity for solving problems in new or unknown environments within broader (or multidisciplinary) contexts related to their area of study.

CB4 - Capability to communicate their conclusions, and the knowledge and rationale underpinning these, to both skilled and unskilled public in a clear and unambiguous way.

CB5 - Possession of the learning skills that enable the students to continue studying in a way that will be mainly self-directed or autonomous.

4. Specific competences

This subject contributes to the following specific competences, as defined in the description of the Degree on Biomedical Engineering of the Public University of Navarra:

CE23 - Knowing and employing sensors, acquisition systems, communication technologies and standards to be applied in study, design and development of tele-monitoring socio-sanitary services.

In the framework of this generic description, this subject contributes to knowing and employing of sensors.

5. Learning outcomes

After pursuing this subject, students will learn:

R1. The most usual magnitudes and figures of merit employed to characterize sensors, especially in biomedical applications.

R2. The most common technologies used for sensor design, especially in biomedical applications.

R3. The main micro and nanofabrication techniques used in biomedical sensors.

R4. The standard working procedures and instrumentation used in laboratories of applied research on sensors.

6. Teaching methodology – Teaching activities

Methodology - Activity	Presential time	Non-presential time
A-1 Expository/participative classes	42	
A-2 Laboratory sessions	18	
A-3 Debates and group tutoring		
A-4 Projects	2	40
A-5 Reading of documents		8
A-6 Individual study		34
A-7 Exams	2	
A-8 Individual tutoring	4	
Total	68	82

7. Relationship between formative activities and competences

Competence	**Formative activity**
CB2, CB4, CB5, CE23	A-1 Expository/participative classes
CB2, CB4, CB5, CE23	A-2 Laboratory sessions
	A-3 Debates and group tutoring
CB2, CB4, CB5, CE23	A-4 Projects
CB2, CB4, CB5, CE23	A-5 Reading of documents
CB2, CB4, CB5, CE23	A-6 Individual study
CE23	A-7 Exams
CB2, CB4, CB5, CE23	A-8 Individual tutoring

8. Languages

This subject will be taught in Spanish. Bibliography will be in English.

9. Evaluation

Learning outcome	Evaluation activity	Weight (%)	Can be repeated?
RA1, RA2, RA3	Exam	40	Yes
RA1, RA2, RA3, RA4	Laboratory session reports	30	No
RA1, RA2, RA3, RA4	Project (in group)	30	Yes

The standard evaluation consists of one exam and of the evaluation of the laboratory session reports and a group project, which must be presented in public.

The re-take evaluation consist of just one exam and one individual project. Each of them corresponds to 50 % of the mark. In this case, in order to pass the subject, a minimum of 4 points out of 10 will be required in this re-take exam.

10. Agenda

The proposed agenda is the following:

1. Introduction
    - 1.1. Basics of sensors
    - 1.2. Introduction to spectroscopic techniques
    - 1.3. Introduction to micro and nanofabrication techniques
    - 1.4. Introduction to sensing techniques applied to the biomedical field

2. Electronic sensors
    - 2.1 Physical electronic sensors
    - 2.2 Chemical electronic sensors
    - 2.3 Biomedical electronic sensors

3. Optical sensors
    - 3.1 Physical optical sensors
    - 3.2 Chemical optical sensors
    - 3.3 Biomedical optical sensors

This subject consists of 6 ECTS and covers one semester (15 weeks). The planned time distribution is: 42 hours of theoretical classes and 18 hours devoted to laboratory sessions (6 sessions of 3 hours each). In the laboratory sessions students will carry out experiments using different types of sensors available in the laboratory.

The proposed laboratory sessions are as follows:

- Session 1: Basics of instrumentation

- Session 2: Physical and chemical electronic sensors
- Session 3: Biomedical electronic sensors
- Session 4: Physical and chemical optical sensors
- Session 5: Biomedical optical sensors
- Session 6: Visit to a microfabrication laboratory

These sessions will be synchronized with the theory, to guarantee that the students have the required knowledge.

11. Bibliography

Basic:

- 'Introduction to Biosensors. From Electric Circuits to Immunosensors', J.-Y. Yoon, Springer, ISBN-13-978-1-4419-6022-1, ISBN-16-978-3-319-27413-3, 262 pp., 2013/2016
- "Sensors Based on Nanostructured Materials"; Francisco J. Arregui; Ed., Springer Science & Business Media, 2010, ISBN 0387777539, 9780387777535
- "Optochemical Nanosensors": A. Cusano, F. J. Arregui, M. Giordano, A. Cutolo; CRC Press , 2012, ISBN 9781439854891

Advanced:

- 'Handbook of Biosensors and Biochips', 2 Volume Set, R.S. Marks, C.R. Lowe, D. C. Cullen, H. H. Weetall, I. Karube, John Wiley & Sons, ISBN: 978-0-470-01905-4, 1500 pp., 2008.
- 'Biosensors for Medical Applications', 1st Edition, S Higson, Woodhead Publishing, eBook ISBN: 9780857097187, Print Book ISBN: 978184569935, 2012.
- "Analysis and design principles of MEMS devices" Editor B. Minhang, Elsevier, 2005. ISBN:0-444-51616-6