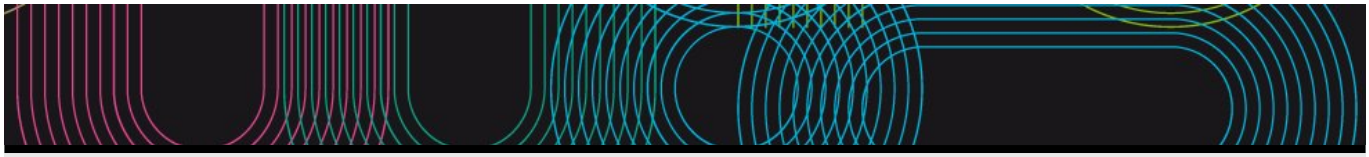

IDENTIFYING DATA				
(*)Tecnoloxías de fabricación aditiva e híbrida aplicada á enxeñaría biomédica				
Subject	(*)Tecnoloxías de fabricación aditiva e híbrida aplicada á enxeñaría biomédica			
Code	V04M192V01307			
Study programme	Máster Universitario en Ingeniería Biomédica			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	4.5	Optional	2nd	1st
Teaching language	#EnglishFriendly Spanish Galician			
Department				
Coordinator	Pérez García, José Antonio Feijoó Vázquez, Iria Pena Uris, Gloria María			
Lecturers	Feijoó Vázquez, Iria Pena Uris, Gloria María Pérez García, José Antonio			
E-mail	japerez@uvigo.es gpena@uvigo.gal ifeijoo@uvigo.es			
Web	http://https://moovi.uvigo.gal/			
General description	In this optional subject, students will acquire the theoretical knowledge and basic practical training to begin modelling and manufacturing biomedical products (prostheses, orthoses, models, and tools for surgery, etc.). This subject is structured with an eminently practical orientation and an integral approach in which, starting from the functional design of a product, the selection of the material that guarantees the appropriate properties, biocompatibility and durability is addressed. Applicable additive and hybrid manufacturing technologies are analyzed, considering quality, safety and economic criteria, and this approach is completed with a review of the post-processing techniques necessary to achieve adequate biomechanical functionality and the best compatibility with physiological environments. Finally, the techniques for verifying the quality of the manufactured part (metrology, microstructural, mechanical and durability characterization) are addressed. English Friendly subject: International students will be able to ask the teaching staff for: a) materials and bibliographic references to follow the subject in English, b) tutorials in English, c) tests and evaluations in English.			

Training and Learning Results	
Code	
A1	Knowledge and understanding that provide a basis or opportunity for originality in developing and / or applying ideas, often in a research context.
A2	That the students can apply their knowledge and their ability to solve problems in new or unfamiliar environments within broader (or multidisciplinary) contexts related to their field of study.
A4	Students can communicate their conclusions, and the knowledge and rationale underpinning these, to specialist and non-specialist audiences clearly and unambiguously.
A5	Students must possess the learning skills that enable them to continue studying in a way that will be largely self-directed or autonomous.
B1	Ability to design, develop, implement, manage and improve products and processes in the different areas of the biomedical engineering, by means of appropriate analytical, computational or experimental techniques.
B4	Ability to solve problems with initiative, decision making, creativity, critical reasoning and to communicate and transmit knowledge, abilities and skills in the field of biomedical engineering.
B10	Knowledge, understanding and ability to apply legislation related to the field of Biomedical Engineering.

Expected results from this subject	
Expected results from this subject	Training and Learning Results
Analyse the characteristics of the main materials used in biomedical implants: metallic, polymers, ceramic, composed and biological.	A1 B10
Knowledge of the design and modelling of implants used in orthopaedics, traumatology and rehabilitation, and dental implants.	A2 A4 B1 B4
Use CAD-CAM tools for the modelling and manufacture of a prosthesis or specific implants.	A2 A4 A5 B1

Contents	
Topic	
1. Introduction	- Historical evolution of additive manufacturing (AM) in the biomedical sector. - Benefits of AF: time and cost reduction, lightening, ergonomic improvements, personalised medicine. - Applications of AF to biomedical products: implants, orthoses, pre-operative models and tooling. - Ethical and legal aspects related to AF in the biomedical field.
2. Functional design of biomedical products	- CADCAM platforms for design and manufacturing - Stages in the design of biomedical products: Definition of functional requirements, preliminary design, optimisation, final design.
3. Biomaterials for additive manufacturing (AM).	- Ceramics: HA, tricalcium phosphate (TCP). Other calcium phosphates (CaPs). Bioglass. Ceramic composites. - Metallics: noble metals, Ti6Al4V, TiNi. 316L, Co-Cr, CoCrMo. Mg alloys. Metal matrix composites. - Polymers: natural biopolymers. Synthetic biopolymers. Polymer-ceramic composites. - Advanced biomaterials for AF.
4. Additive manufacturing technologies applied to biomedical products.	- Fused deposition modeling (FDM) - Tank or vat light curing (SLA) - Powder bed fusion (SLS) - Binder injection (BJ) - Localized energy deposition (DED) - Electron beam powder bed melting (EBM) - Bioprinting - Multi-material and hybrid manufacturing.
5. Product quality control	- Analysis of the effect of printing parameters on product properties. - Post-processing and surface treatments. - Structural, mechanical, thermal and chemical characterisation. Related regulations and standards.
6. Design and manufacturing project	- Study cases - Initial design: particular conditioning factors. Topological optimization - Initial printing tests: Influence of deposition parameters on properties. - Manufacture of parts. - Analysis of the results obtained. Lessons learned

Planning			
	Class hours	Hours outside the classroom	Total hours
Introductory activities	1	0	1
Lecturing	23	46	69
Practices through ICT	4	2	6
Laboratory practical	4	5	9
Mentored work	4	20	24
Self-assessment	0.5	0	0.5
Report of practices, practicum and external practices	0.5	0	0.5
Presentation	0.5	0	0.5
Objective questions exam	2	0	2
*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.			

Methodologies

	Description
Introductory activities	The teaching staff present the course: contents, organisation, methodologies used, timetable and assessment system. Special attention is paid to the description of the projects to be developed by the students (tutored work) as well as the system of tutorials and support available to the students.
Lecturing	The teacher will present and explain the fundamental contents of the subject, encouraging the active participation of the students. The material used in the presentations will be available to students beforehand on the Moovi platform. Manipulative activities may be carried out in the classroom.
Practices through ICT	They will take place in a IT classroom. In these practical sessions teachers will guide students in the use of CADCAM platforms for the design of simple biomedical products, and also in the use of CESEDUPACK program for the adequate selection of materials.
Laboratory practical	Practical application activities of the knowledge acquired in the theoretical sessions. These are carried out in the laboratory with specialised equipment and in accordance with the applicable standards. In these activities, the teaching staff will guide the student in the use of the equipment and techniques to be used in the development of the project, such as AD technologies, machining and metrology, mechanical, thermal and microstructural characterisation equipment.
Mentored work	This project or supervised work involves the direct application of all the knowledge acquired during the course. The teaching staff will propose various biomedical products to the students so that each of the students (or in groups of two, depending on their number) can carry out the complete process of requirements analysis, design, material selection, manufacture and characterisation. The students will have access to the equipments of the centre and the support of the teaching staff to carry it out.

Personalized assistance

Methodologies	**Description**
Lecturing	The teacher will guide and solve any doubts that the student may have in relation to the contents explained in the Lectures. This attention will take place spontaneously in the classroom, and in tutorial sessions. The tutorials may be individual or small group, at the student's request, during the timetable defined by the teaching staff.
Practices through ICT	The laboratory teachers will guide the students in the development of the practical classes, clarifying doubts and guiding them to achieve the best understanding of the concepts and the acquisition of the necessary skills. This attention will be carried out spontaneously throughout the practical sessions, and also in personalized tutoring sessions, following the scheduled sessions defined by the teaching staff.
Mentored work	During the development of the project, which the students will have to carry out individually or in small groups, they will have the guidance and help of the teaching staff. This attention will be given when required, during the timetable established by the teaching staff. However, two group tutoring sessions will be proposed, one at the beginning of the project and the other before the defence, in order to be able to modify those aspects of the structure or content that need it.
Tests	**Description**
Self-assessment	The teacher will design the self-assessment questionnaires that students will have to answer at the end of each lesson or thematic unit. The self-assessment will take place in the classroom, on a day and at a time set sufficiently in advance. The teaching staff will help to resolve any technical questions that may arise.
Report of practices, practicum and external practices	Students will have the support of the laboratory lecturers to resolve any concerns that may arise in the writing of the practical reports or in the answers to the questions asked.

Assessment

	Description	Qualification	Training and Learning Results

Self-assessment	At the end of each topic or thematic unit, there will be a short self-assessment test that students will have to answer individually. The results of these tests will guide students on their understanding of the subject and their progress in learning. The tests will consist of the resolution of 10 multiple choice questions (single or multiple answer), online, through the Moovi platform. They will take place in the classroom itself, in the time allocated to the lectures. The dates and times of these tests will be communicated to students sufficiently in advance through the teaching platform and in the classroom itself. Students must have a laptop or mobile phone that allows connection to the platform.	20	A2 A5	B4
Report of practices, practicum and external practices	After each practical session (ICT and laboratory), the student must hand in a report including the results of the tests carried out as well as the answers to the questions posed.	10	A2 A5	B4
Presentation	Oral presentation in which each student (or small group, depending on the number of students) presents and defends the project carried out before the teacher and their classmates. The student must explain the steps followed in each of the stages of development of the project, demonstrating the knowledge and skills acquired. At the end of the presentation, the student must answer questions from the teacher and the rest of the students. This presentation and defence will be assessed according to a previously published rubric.	40	A1 A2 A4	B1 B4 B10
Objective questions exam	A written test will be held on the dates scheduled by the centre. This exam will assess the knowledge that students have acquired of the concepts presented in the theory classes, through short questions, exercises, etc.	30	A2 A5	B4 B10

Other comments on the Evaluation

Continuous assessment (this will be the preferred assessment system): Consists of various tests to be taken throughout the teaching period, and a written test to be taken on the official **1st Attempt** exam date, as indicated in the table above, in which the percentage of each test is included in the final mark. As a summary:

- Self-assessment: 20%.
- Practical work and report: 10%.
- Presentation of the project: 40%.
- Written exam: 30%.

- Students who follow the continuous assessment procedure **must compulsorily participate in all the activities** indicated above, and their final grade will be the sum of the marks obtained in each of the tests, with the weighting indicated in the table above. In order to pass the continuous assessment of the subject, a mark equal to or higher than 5 points out of 10 must be obtained.

- In **exceptional cases** in which a student is unable to participate in a specific session of the above activities, the teaching staff will agree with the student on an alternative activity or test, which will allow him/her to continue with the development of the subject without prejudice to the evaluation process.

- Students who must sit the **second assessment attempt** will keep the grade obtained in the Self-assessment and Practical Reports tests (30%), but must take a written exam of objective questions that will evaluate the theoretical contents of the course (30% of the final grade) and carry out the presentation of the project (40%). The exam will take place on the official date established by the centre.

Global or comprehensive assessment: Students who do not wish to take part in the continuous assessment procedure must follow the **procedure for waiving continuous assessment** established by the management of the IEE, complying with the deadlines set by the centre. In this case, **both in the first and in the second edition,** the assessment will be carried out by means of a written exam (50% of the final mark), and the defence of a comprehensive project selected from those proposed by the teaching staff including analysis, design, manufacturing and characterization of a medical product (50% of the final mark). The assessment will be carried out on the official dates established by the centre. In order to pass the overall assessment, the student must achieve a minimum mark of 5 out of 10.

Extraordinary Call: to be held according to the global assessment system described above, on the date previously set by the centre.

Ethical commitment: Students are expected to behave ethically in accordance with the code of ethics of the University of Vigo and the IEE. According to article 42.1 of the ***Regulation on the evaluation, grading and quality of teaching and the learning process of students at the University of Vigo***, (Approved in closing on 18 April 2023): "Fraudulent

performance in any assessment test will result in a grade of zero (fail) in the minutes of the corresponding assessment opportunity, regardless of the value that the test in question has on the overall grade and without prejudice to the possible consequences of a disciplinary nature that may occur".

NOTE: In the event of discrepancies or inconsistencies in the information contained in the different language versions of this guide, the version published in Spanish will prevail.

Sources of information

Basic Bibliography

Sheku Kamara, K. S. Faggiani, Ed., **Fundamentals of Additive manufacturing for the pradtitioner**, Wiley, 2021

Kun Zhou, Ed., **Additive Manufacturing Technology**, WILEY-VCH, 2023

Venina dos Santos, Rosmary Nichele Brandalise, Michele Savaris, **Engineering of Biomaterials**, Springer, 2017

Roger Narayan, Ed., **Rapid prototyping of biomaterials : principles and applications**, Philadelphia, PA : Woodhead Pub, 2014

Atul Babbar, Ankit Sharma, Vivek Jain, and Dheeraj Gupta, Eds., **Additive manufacturing processes in biomedical engineering : advanced fabrication methods and rapid tooling techniques**, Boca Raton : CRC Press, 2023

Zafar Alam Faiz, Iqbal Dilshad, Ahmad Khan, Eds, **Post-processing Techniques for Additive Manufacturing**, CRC Press, 2024

Complementary Bibliography

William Murphy, Jonathan Black, Garth Hastings Eds., **Handbook of Biomaterial Properties**, 2ª Ed, Springer, 2016

Recommendations

Subjects that are recommended to be taken simultaneously

(*)Certificación de productos sanitarios e innovación en tecnoloxía médica/V04M192V01302
(*)Simulación biomecánica/V04M192V01308

Subjects that it is recommended to have taken before

(*)Análisis biomecánico de actividades e funcións humanas/V04M192V01105
(*)Deseño de produtos e servizos intelixentes no sector biomédico/V04M192V01209
(*)Enxeñaría de superficies para aplicacións biomédicas/V04M192V01205