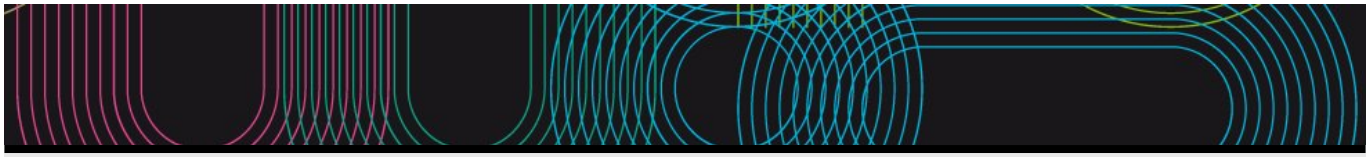
Universidade Vigo

Subject Guide 2023 / 2024



IDENTIFYING DATA				
Applications in Biomedical Engineering				
Subject	Applications in Biomedical Engineering			
Code	V04M196V01202			
Study programme	Máster Universitario en Fabricación Aditiva			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Optional	1st	2nd
Teaching language	#EnglishFriendly Spanish Galician			
Department				
Coordinator	Pena Uris, Gloria María			
Lecturers	Casarejos Ruiz, Enrique Feijoó Vázquez, Iria Hernández Martín, Primo Pena Uris, Gloria María Segade Robleda, Abraham			
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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	
B6	Perform simulation and modeling processes for 3D design and prototyping of materials, as well as for simulation of structures and manufacturing processes.
B7	Define the technical requirements of the different products to be developed and select the most appropriate additive manufacturing tools and technologies.
B9	Define the 3D printing method taking into account the characteristics of the object to be produced.
B11	Recognise the possibilities of additive manufacturing versus traditional manufacturing.
C1	To know and apply techniques of characterization and analysis of materials (metals, ceramics, composites, polymers...) in order to understand their properties and identify potential uses.
C4	Select materials for specific manufacturing applications from the specifications of the additive manufacturing tools and printers to be used, as well as from the different types of existing modeling.
C7	Analyze the characteristics of the objects to be produced in order to select the most suitable printing method.
D7	Design and redefine objects using parametric design tools to perform 3D printing.
D9	Inspeccionar los productos o piezas fabricadas con el fin de verificar el cumplimiento de las normas de calidad y el cumplimiento de las características técnicas establecidas

Expected results from this subject

Expected results from this subject	Training and Learning Results
New	B6 B7 B9 B11
New	C1 C4 C7
New	D7 D9

Contents

Topic	
1. Introduction to additive manufacturing in the biomedical sector.	Historical evolution of additive manufacturing (AM) in the biomedical sector. Benefits of AM: time and cost reduction, weight lightening, ergonomic improvements, personalised medicine. Applications of AM to biomedical products: protheses, orthoses, pre-operative models and tooling. Ethical and legal aspects related to AM in the biomedical field.
2. Numerical modelling and simulation in additive manufacturing. Biomedical sector.	Importance of numerical simulation. FEM calculation bases and topological optimisation. Preprocessing: - Preparation of geometry for FEM. - Boundary conditions and application of loads. - Material models. Post-processing in modelling: - Stress and strain analysis with focus on static testing. - Structural analysis, failure criteria. - Topological optimisation.
3. Biomaterials for Additive Manufacturing	General characteristics of biomaterials. Classification. 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 (AF) 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 melting (EBM) Multi-material manufacturing Bioprinting
5. Product quality control. Post-processing.	Analysis of the effect of printing parameters on product properties. Post-processing and surface treatments of parts. Structural, mechanical, thermal and chemical characterization. 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	0.5	0	0.5
Lecturing	15	45	60
Practices through ICT	6	0	6
Laboratory practical	6	0	6
Mentored work	20	54.5	74.5
Self-assessment	0.5	0	0.5
Report of practices, practicum and external practices	0.5	0	0.5

Objective questions exam	1.5	0	1.5
Presentation	0.5	0	0.5

*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 evaluation system. A description of the projects to be developed by the students is given, as well as the conditions for carrying them out. The tutoring and support system available to students is explained.
Lecturing	The teachers 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 computer classroom. Practical sessions in which the teaching staff guide students in the use of the platforms and platforms and programmes for design, modelling and simulation, as well as the CESEDUPACK programme for the selection of materials.
Laboratory practical	Practical application activities of the knowledge acquired in the lectures. 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 FA technologies, machining and metrology, mechanical, thermal and microstructural characterisation.
Mentored work	This menotred work or project involves the direct application of the knowledge acquired and will allow the development of the necessary practical integration skills. The teaching staff will propose several simple biomedical products for the students (individually or in small groups, depending on the number of students) to carry out the complete process of requirements analysis, design, material selection, manufacture and characterisation. To do this, students will have the facilities of the centre and the support of the teaching staff.

Personalized assistance

Methodologies	Description
Lecturing	The teacher will guide and resolve any doubts that the student may have in relation to the topics explained in the theory classes. This attention will take place in the classroom itself, spontaneously and in tutorial sessions. Tutorials will be held at the request of the students, during the timetable defined by the teaching staff, and may be individual or in small groups.
Practices through ICT	The teaching staff will guide students in the use of the programmes and platforms, clarifying their doubts and guiding them to achieve the best understanding of the concepts and the acquisition of the necessary skills. This attention will be given spontaneously during the practical sessions and also in personalised tutoring sessions. These will take place during the timetable defined by the teaching staff.
Laboratory practical	The laboratory teachers will guide the students in the development of the practical classes, clarifying their doubts and guiding them in order to achieve a better understanding of the concepts and the acquisition of the necessary skills in the use of the different techniques. This attention will be given spontaneously during the practical sessions and also in personalised tutoring sessions. These will take place during the timetable 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 during the execution of the tasks of the project itself, or if necessary, when required, within 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.

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 in the lectures time. The dates and times of these tests will be communicated to students ufficiently in advance through the teaching platform and in the classroom.Students must have a laptop computer or mobile phone that allows connection to the platform.	20	B7 B9 B11	C1
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	B6 B7 B9 B11	C1 C4 C7
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	B7 B9 B11	C1
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 the questions asked by the teaching staff and the rest of the students. This presentation and defence will be evaluated according to a previously published rubric.	40		C1 D7 C4 D9 C7

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

Pedro A. Carrión Pérez, **Modelado y simulación : ingeniería biomédica**, 978-84-8427-689-0, Universidad de Castilla-La Mancha, 2010

Lee, Huei-Huang, **Finite element simulations with ANSYS Workbench 19 : theory, applications, case studies**, Mission, KS : SDC Publications, 2018

Madenci, Erdogan, **The finite element method and applications in engineering using ANSYS**, New York : Springer, cop, 2015

Damir Godec, Joamin Gonzalez-Gutierrez, Axel Nordin, Eujin Pei, Julia Ureña Alcázar, **A Guide to Additive Manufacturing**, Springer, 2022

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

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

William Wagner, Shelly Sakiyama-Elbert, Guigen Zhang, Michael Yaszemski, Eds, **Biomaterials Science An Introduction to Materials in Medicine**, 9780128161371, 4th Edition, Academic Press, Elsevier, 2020

Complementary Bibliography

Ugo Andreaus, Daniela Iacoviello, Eds., **Biomedical Imaging and Computational Modeling in Biomechanics**, 94-007-4269-X, Springer, 2013

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

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

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

Recommendations

Subjects that continue the syllabus

External practices/V04M196V01205
Final Master's Project/V04M196V01206

Subjects that are recommended to be taken simultaneously

Automotive applications/V04M196V01201

Other comments

It is recommended that students have passed or, at least, attended all the subjects of the semester before taking this subject.