



## (\*)Escola de Enxeñaría Industrial

### Information

For additional information about the centre and its degrees visit the centre's website <https://eei.uvigo.es/>

## Máster Universitario en Fabricación Aditiva

### Subjects

#### Year 1st

| Code          | Name                                                           | Quadmester | Total Cr. |
|---------------|----------------------------------------------------------------|------------|-----------|
| V04M196V01101 | Product design and development                                 | 1st        | 6         |
| V04M196V01102 | Manufacturing technologies                                     | 1st        | 6         |
| V04M196V01103 | Materials                                                      | 1st        | 6         |
| V04M196V01104 | Entrepreneurship, project management and intellectual property | 1st        | 3         |
| V04M196V01105 | Integration with other technologies                            | 1st        | 3         |
| V04M196V01106 | Workshop                                                       | 1st        | 6         |
| V04M196V01201 | Automotive applications                                        | 2nd        | 6         |
| V04M196V01202 | Applications in Biomedical Engineering                         | 2nd        | 6         |
| V04M196V01203 | Applications in energy and sustainability                      | 2nd        | 6         |
| V04M196V01204 | Advanced design for 3D printing                                | 2nd        | 6         |
| V04M196V01205 | External practices                                             | 2nd        | 6         |
| V04M196V01206 | Final Master's Project                                         | 2nd        | 12        |

| IDENTIFYING DATA                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |           |      |            |
|-------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|------|------------|
| Deseño e desenvolvemento do produto |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |           |      |            |
| Subject                             | Deseño e desenvolvemento do produto                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |           |      |            |
| Code                                | V04M196V01101                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |           |      |            |
| Study programme                     | Máster Universitario en Fabricación Aditiva                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |           |      |            |
| Descriptors                         | ECTS Credits                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Choose    | Year | Quadmester |
|                                     | 6                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Mandatory | 1    | 1c         |
| Teaching language                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |           |      |            |
| Department                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |           |      |            |
| Coordinator                         | Cerqueiro Pequeño, Jorge                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |           |      |            |
| Lecturers                           | Cerqueiro Pequeño, Jorge<br>Comesaña Campos, Alberto                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |           |      |            |
| E-mail                              | jcerquei@uvigo.es                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |           |      |            |
| Web                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |           |      |            |
| General description                 | <p>O obxectivo desta materia é que o alumno se achegue ao Deseño e Desenvolvemento de Produto desde o punto de vista da Enxeñería en Deseño Industrial e tamén saiba aplicalo ao Deseño e Desenvolvemento de Produto desde o punto de vista da fabricación aditiva.</p> <p>O alumno achegárase aos Proxectos de Deseño Industrial coñecendo a metodoloxía de desenvolvemento dos mesmos. Realizarán proxectos prácticos de creación de novos conceptos de produto e como condicionante de deseño aplicarase a fabricación aditiva. Finalmente, preténdese a adquisición de competencias para a simulación mediante elementos finitos dos sistemas estruturais obtidos mediante fabricación aditiva.</p> |           |      |            |

### Resultados de Formación e Aprendizaxe

|      |                                                                                                                                                                       |
|------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Code |                                                                                                                                                                       |
| B6   | Realizar procesos de simulación e modelado para o deseño 3D e prototipado de materiais, así como para a simulación de estruturas e procesos de fabricación.           |
| B10  | Realizar adaptacións do deseño de obxecto tendo en conta o método de impresión utilizado e os correspondentes criterios de seguridade, eficiencia e sustentabilidade. |
| C10  | Aplicar técnicas de enxeñería inversa para reproducir elementos mediante impresión 3D.                                                                                |
| D7   | Deseñar e redefinir obxectos utilizando ferramentas de deseño paramétrico para realizar impresión 3D                                                                  |

### Resultados previstos na materia

|                                                                                                                                                                              |                               |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|
| Expected results from this subject                                                                                                                                           | Training and Learning Results |
| RA 6: Realizar procesos de simulación e modelado para o deseño 3D e prototipado de materiais, así como para a simulación de estruturas e procesos de fabricación.            | B6                            |
| RA 10: Realizar adaptacións do deseño de obxecto tendo en conta o método de impresión utilizado e os correspondentes criterios de seguridade, eficiencia e sustentabilidade. | B10                           |
| RA 21: Aplicar técnicas de enxeñería inversa para reproducir elementos mediante impresión 3D.                                                                                | C10                           |
| RA 28: Deseñar e redefinir obxectos utilizando ferramentas de deseño paramétrico para realizar impresión 3D                                                                  | D7                            |

### Contidos

|                                       |                                                                                                                                                                                                                             |
|---------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Topic                                 |                                                                                                                                                                                                                             |
| 1. DESEÑO E PRODUTO.                  | 1.1. Prego de Condicións dos proxectos.<br>1.2. Fase de Información.<br>1.3. Fase de Conceptualización.<br>1.4. Fase de Desenvolvemento.<br>1.5. Fase Final.<br>1.6. Documentación.<br>1.7. Presentación.<br>1.8. Maquetas. |
| 2. XEOMETRÍAS NA FABRICACIÓN ADITIVA. | 2.1. Captura de xeometrías.<br>2.2. Manipulación de xeometrías.<br>2.3. CAD. Modelado paramétrico e non paramétrico.<br>2.4. Exportación e intercambio entre CAD e CAM.<br>2.5. CAM. Laminado de xeometrías.                |

### 3. CALCULO ESTRUCTURAL EN FABRICACIÓN ADITIVA.

3.1 Formulación xeral do Método de Elementos Finitos.  
3.2 Modelización mediante elementos finitos. Familias de elementos finitos. Elementos continuos e estruturais. Materiais e propiedades mecánicas. Ensamblaxe. Imposición de restricións. Interaccións.  
3.2 Simulación mediante elementos finitos. Imposición de cargas e condicións de contorno. Resolución de problemas e avaliación de resultados.

#### Planificación

|                               | Class hours | Hours outside the classroom | Total hours |
|-------------------------------|-------------|-----------------------------|-------------|
| Prácticas de laboratorio      | 4.5         | 10                          | 14.5        |
| Estudo de casos               | 6           | 13                          | 19          |
| Traballo tutelado             | 23          | 54                          | 77          |
| Lección maxistral             | 16.5        | 20                          | 36.5        |
| Exame de preguntas obxectivas | 3           | 0                           | 3           |

\*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

#### Metodoloxía docente

|                          | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|--------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Prácticas de laboratorio | Metodoloxía que permite que os estudantes aprendan efectivamente a través da realización de actividades de carácter práctico, tales como demostracións, exercicios, experimentos e investigacións.                                                                                                                                                                                                                                                                                                      |
| Estudo de casos          | Técnica de traballo en grupo que ten como finalidade o estudo intensivo dun tema. Caracterízase pola discusión, a participación, a elaboración de documentos e as conclusións ás que teñen que chegar todos os compoñentes do seminario.                                                                                                                                                                                                                                                                |
| Traballo tutelado        | Metodoloxía deseñada para promover a aprendizaxe autónoma dos estudantes, baixo a tutela do profesor e en escenarios variados (académicos e profesionais). Está referida prioritariamente á aprendizaxe do "como facer as cousas". Constitúe unha opción baseada na asunción polos estudantes da responsabilidade pola súa propia aprendizaxe. Este sistema de ensino baséase en dous elementos básicos: a aprendizaxe independente dos estudantes e o seguimento desa aprendizaxe polo profesor-titor. |
| Lección maxistral        | Exposición oral complementada co uso de medios audiovisuais e a introdución dalgunhas preguntas dirixidas aos estudantes, coa finalidade de transmitir coñecementos e facilitar a aprendizaxe.                                                                                                                                                                                                                                                                                                          |

#### Atención personalizada

| Methodologies            | Description                                                                                                                                                                                                                                                                                                                        |
|--------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Prácticas de laboratorio | O estudante acode ao profesor ou os profesores da materia para consultar as dúbidas que lle xorden durante a realización das prácticas de laboratorio e dos traballos tutelados. Ademais mediante esta atención personalizada realízase un seguimento e orientación crítica do proceso de traballo que realiza o alumno ou alumna. |
| Estudo de casos          | O estudante acode ao profesor ou os profesores da materia para consultar as dúbidas que lle xorden durante a realización das prácticas de laboratorio e dos traballos tutelados. Ademais mediante esta atención personalizada realízase un seguimento e orientación crítica do proceso de traballo que realiza o alumno ou alumna. |
| Traballo tutelado        | O estudante acode ao profesor ou os profesores da materia para consultar as dúbidas que lle xorden durante a realización das prácticas de laboratorio e dos traballos tutelados. Ademais mediante esta atención personalizada realízase un seguimento e orientación crítica do proceso de traballo que realiza o alumno ou alumna. |

#### Avaliación

|                               | Description                                                                                                                                                                                                                                                                       | Qualification | Training and Learning Results |     |    |
|-------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|-------------------------------|-----|----|
| Prácticas de laboratorio      | Hai que asistir sistematicamente ás prácticas e elaboralas durante as sesións prácticas da materia e nas horas non presenciais asignadas. O seguimento do traballo realízase nestas sesións prácticas. A avaliación realízase mediante a presentación dos informes das prácticas. | 30            | B6<br>B10                     | C10 | D7 |
| Traballo tutelado             | O seguimento da realización do traballo realízase nas sesións prácticas. A avaliación realízase mediante a presentación do traballo tutelado                                                                                                                                      | 40            | B6<br>B10                     | C10 | D7 |
| Exame de preguntas obxectivas | Exame de preguntas e respostas estruturado en diferentes partes                                                                                                                                                                                                                   | 30            | B6<br>B10                     | C10 | D7 |

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### Other comments on the Evaluation

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A materia está pensada para asistir sistemáticamente ás sesións presenciais e desenvolver as actividades docentes propostas, cun seguimento e/ou avaliación das mesmas nas devanditas sesións prácticas.

Os criterios de avaliación para a segunda oportunidade serán os mesmos que os da primeira oportunidade, salvo para os traballos tutelados, que serán avaliados unicamente na primeira oportunidade, manténdose esa cualificación para a segunda oportunidade, no caso de ter que concorrer a esta.

A dispensa académica é aceptada. Este estudante, cuxa presenza ao longo do cuadrimestre sexa insuficiente para realizar o traballo ou o seguimento do traballo, será avaliado cos mesmos criterios que os da segunda oportunidade.

Os criterios de avaliación da convocatoria adiantada de decembro serán os mesmos que os da segunda oportunidade do ano anterior.

A fraude comprobada en calquera actividade de traballo, proba ou avaliación dará lugar á cualificación de suspenso de "0" na actividade de traballo, proba ou avaliación que se trate.

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### Bibliografía. Fontes de información

#### Basic Bibliography

Bathe K.J., **Finite Elements Procedures**, Prentice-Hall, Pearson Education, Inc. USA, 2006

Chua, C.K.; Leong, K.F., **Rapid prototyping principles and applications**, World Scientific, 2017

Cooper, K.G., **Rapid prototyping technology selection and application**, CRC Press, 2001

Gebhardt, A., **Rapid prototyping**, Hanser Publishers, 2003

Gutiérrez, R. ; Bayo, E.; Loureiro, A.; Romera, L.E., **Estructuras II**, Reprografía del Noroeste. Santiago de Compostela., 2010

Lee, H.-H., **Finite element simulations with ANSYS Workbench 19 : Theory, applications, case studies**,

9781630572112, Mission, KS : SDC Publications, 2018

Liou, F.W., **Rapid prototyping and engineering applications: A toolbox for prototype development**, CRC Press, 2019

Munari, B., **Cómo nacen los objetos**, Editorial GG - Gustavo Gili, 2016

Powell, D., **Técnicas de Presentación**, Editorial Blume,

RepRap, <http://reprap.org>,

Shen, J.; Walker, T.D., **Sketching and rendering for design presentations**, Van Nostrand Reinhold, 1992

Wong, W., **Fundamentos del diseño**, Editorial GG - Gustavo Gili, 1995

#### Complementary Bibliography

Dassault Systèmes Simulia Corp., **Abaqus 2014 documentation**, Dassault Systèmes. Providence, RI, USA, 2014

Emerald, **Rapid Prototyping Journal**, Emerald,

Oñate, E., **Calculo de estructuras por el método de elementos finitos**, CIMNE, Barcelona, España, 1995

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### Recomendacións

#### Subjects that continue the syllabus

Diseño avanzado para impresión 3D/V04M196V01204

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### Other comments

As comunicacións cos estudantes faranse a través da Plataforma de teledocencia MOOVI, polo que é necesario que o estudante acceda ao espazo da materia na plataforma previamente ao comezo da docencia.

Antes da realización das probas de avaliación, recoméndase consultar a Plataforma MOOVI para confirmar a data, lugar, recomendacións, etc., así como a necesidade de dispor de normativa, manuais ou calquera outro material para a realización dos exames e resolución de traballos non presenciais.

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| <b>IDENTIFYING DATA</b>           |                                                                                                                                                                                                                        |           |      |            |
|-----------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|------|------------|
| <b>Manufacturing technologies</b> |                                                                                                                                                                                                                        |           |      |            |
| Subject                           | Manufacturing technologies                                                                                                                                                                                             |           |      |            |
| Code                              | V04M196V01102                                                                                                                                                                                                          |           |      |            |
| Study programme                   | Máster Universitario en Fabricación Aditiva                                                                                                                                                                            |           |      |            |
| Descriptors                       | ECTS Credits                                                                                                                                                                                                           | Choose    | Year | Quadmester |
|                                   | 6                                                                                                                                                                                                                      | Mandatory | 1st  | 1st        |
| Teaching language                 | #EnglishFriendly<br>Spanish<br>Galician                                                                                                                                                                                |           |      |            |
| Department                        |                                                                                                                                                                                                                        |           |      |            |
| Coordinator                       | Pérez García, José Antonio                                                                                                                                                                                             |           |      |            |
| Lecturers                         | Pérez García, José Antonio<br>Prado Cerqueira, María Teresa                                                                                                                                                            |           |      |            |
| E-mail                            | japerez@uvigo.es                                                                                                                                                                                                       |           |      |            |
| Web                               | http://moovi.uvigo.gal/                                                                                                                                                                                                |           |      |            |
| General description               | Manufacturing technologies provide unprecedented transformation for the profitability and competitiveness of companies. Among the technologies that have recently transformed manufacturing is Additive Manufacturing. |           |      |            |

### Training and Learning Results

|      |                                                                                                                                                                   |
|------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Code |                                                                                                                                                                   |
| B1   | Define printing methods, safety and efficiency criteria to adapt the design of objects to 3D printing.                                                            |
| B3   | Identify production requirements to adapt them to the new additive production systems.                                                                            |
| B4   | Define quality, safety and environmental requirements in additive manufacturing environments for integration into the production control management system.       |
| B8   | Identify the stages of the additive manufacturing production process.                                                                                             |
| C2   | To know and apply legal and environmental regulations, establishing protocols for the management of waste generated in the manufacturing process of the products. |
| D4   | Combine and integrate different technologies in additive manufacturing processes.                                                                                 |
| D6   | Design the different products according to the technical requirements offered by the different additive manufacturing tools and technologies.                     |

### Expected results from this subject

| Expected results from this subject | Training and Learning Results |
|------------------------------------|-------------------------------|
| Knowledge                          | B1<br>B3<br>B4<br>B8          |
| Skill                              | C2                            |
| Competences                        | D4<br>D6                      |

### Contents

|                                                                                                                               |                                                                                                                                                                                                                                                                                |
|-------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Topic                                                                                                                         |                                                                                                                                                                                                                                                                                |
| Module 1.- Introduction                                                                                                       | - Introduction to the production cycle<br>- Concurrent engineering<br>- Classification of Manufacturing Technologies                                                                                                                                                           |
| Module 2.- Subtractive manufacturing techniques vs additive manufacturing techniques                                          | - Subtractive manufacturing techniques<br>- Additive manufacturing techniques<br>- Hybrid manufacturing techniques                                                                                                                                                             |
| Module 3.- Classification of additive manufacturing techniques according to UNE-EN ISO ASTM 52900 and UNE-EN ISO 17296-2:2017 | - Material extrusion (ME): FDM<br>- Focused Energy Deposition (DED): DED-L, DED-arc.<br>- Powder bed fusion (PBF): SLS, SLM, EBM.<br>- Material projection (MJ).<br>- Sheet laminate (LOM, UC).<br>- Photopolymerization in tank or vat (VP): SLA.<br>- Binder injection (BJ). |
| Module 4.- Joining processes derived from additive manufacturing techniques                                                   | - Stir additive manufacturing (FSAM)<br>- Additive friction stir deposition (AFSD)<br>- Others                                                                                                                                                                                 |

|                                                                                         |                                                                                                                                                                                         |
|-----------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Module 5.- CAD/CAE/CAM Technologies in Additive and Hybrid Manufacturing.               | <ul style="list-style-type: none"> <li>- Desing assisted by computer</li> <li>- Material selection</li> <li>- Preprocessing</li> <li>- Resolution</li> <li>- Post processing</li> </ul> |
| Module 6.- Applicability of additive manufacturing                                      | <ul style="list-style-type: none"> <li>- Automotive sector</li> <li>- Aeronautic sector</li> <li>- Biomedical sector</li> </ul>                                                         |
| Module 7.- Quality assurance                                                            | <ul style="list-style-type: none"> <li>- Dimensional control</li> <li>- Surface quality control</li> <li>- Control of mechanical propertie</li> </ul>                                   |
| Module 8.- Management of additive manufacturing systems                                 | <ul style="list-style-type: none"> <li>- Production Vs. maintenance</li> <li>- Types of maintenance</li> <li>- TPM</li> </ul>                                                           |
| Module 9.- Risk prevention and occupational health in additive manufacturing processes  | <ul style="list-style-type: none"> <li>- Basic concepts on safety and health at work</li> <li>- Working conditions and risk factors in additive manufacturing processes</li> </ul>      |
| Module 10.- Specific regulations on the development of additive manufacturing processes | <ul style="list-style-type: none"> <li>- UNE-EN ISO/ASTM 52910:2020</li> <li>- DIN SPEC 1071</li> </ul>                                                                                 |

## Planning

|                          | Class hours | Hours outside the classroom | Total hours |
|--------------------------|-------------|-----------------------------|-------------|
| Introductory activities  | 3           | 3                           | 6           |
| Lecturing                | 10.5        | 15                          | 25.5        |
| Simulation               | 10.5        | 15                          | 25.5        |
| Project based learning   | 21          | 32                          | 53          |
| Project                  | 2           | 30                          | 32          |
| Presentation             | 1           | 6                           | 7           |
| Objective questions exam | 1           | 0                           | 1           |

\*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 | 2 Sessions of 1.5 hours each in which, after explaining to the students what the project-based learning methodology consists of, they will be informed of the roadmap to follow during the course                              |
| Lecturing               | 7 sessions of 1.5 hours each, in which the theoretical concepts included in the course agenda will be explained                                                                                                                |
| Simulation              | 7 sesións de 1,5 horas cada unha, a realizar no Taller da Área IPF da EEI (Campus Lagoas Marcosende) centradas na aprendizaxe tanto do software CAM como dos equipos de fabricación que o alumno debe manexar durante o curso. |
| Project based learning  | 14 sessions of 1.5 hours, to be held in the Workshop of the IPF Area of the EEI (Campus Lagoas Marcosende) focused on the development of real projects for the design and manufacture of tools and components.                 |

## Personalized assistance

| Methodologies          | Description                                                                                 |
|------------------------|---------------------------------------------------------------------------------------------|
| Project based learning | A tutorial schedule will be established, both face-to-face and online through Remote Campus |
| Lecturing              | A tutorial schedule will be established, both face-to-face and online through Remote Campus |
| Tests                  | Description                                                                                 |
| Project                | A tutorial schedule will be established, both face-to-face and online through Remote Campus |

## Assessment

|              | Description                                                                                                                                                                                                                                        | Qualification Training and Learning Results |
|--------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------|
| Project      | The student will carry out a practical project. In its preparation, you will use the CAD/CAM/CAE Autodesk Inventor Professional software and the manufacturing equipment available in the manufacturing workshop of the IPF Area at the EEI Campus | 50                                          |
| Presentation | The student will document and present the project developed during the course                                                                                                                                                                      | 20                                          |

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## Other comments on the Evaluation

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### FIRST CHANCE (January)

#### a) Continuous Assessment Modality

The continuous evaluation will be carried out during the teaching period of the subject. In this modality, all tests are compulsory. The contribution of each test to the total grade is as follows:

- 1) First Work Report. At the beginning of the project, the student will present a first report in which he will detail both the objectives of the work and the resources and the execution planning, having to demonstrate both the suitability of the chosen topic and the feasibility of its manufacture with the resources available in the workshop. Mechanic of the IPF Area at the EEI Campus Headquarters (10% of the qualification).
- 2) Second Work Report. Halfway through the project, the student will present a second report that reflects the status of the project's evolution, analyzes the degree of compliance with the initially planned plan and, if necessary, proposes possible corrective measures necessary to achieve final compliance with the planned objectives ( 20% of the grade)
- 3) Final Work Report. This report, which will constitute the memory of the work, will constitute the final documentation of the work, that is, calculations, plans, process sheets, costs, □. (20% of the grade).
- 4) Presentation of the Work. After the delivery of the Final Work Report, the student will make a public presentation of it (20% of the grade).
- 5) At the end of the course, the student must take an evaluation exam of the different theoretical aspects developed during the course (30% of the grade).

To pass the subject in the first edition of the certificate by continuous evaluation, a minimum of 40% must be reached in each of the previously written tests. In the event that the student does not reach this minimum in any of the Continuous Assessment tests or, having reached it, does not achieve a minimum of 5 (scale 0 to 10) in the overall subject, it will be considered that they have not passed the exam. subject and must be submitted to the Second Chance (June/July).

In the case of not reaching the minimum in any continuous assessment test, and the sum of the qualifications is greater than 5 (scale 0 to 10), the record will include 4.9.

#### b) Overall Assessment Modality.

Those students who renounce the continuous evaluation methodology and therefore use the global evaluation methodology, will be evaluated solely on the basis of:

1. Final Work Report. This report, which will constitute the memory of the work, will constitute the final documentation of the work, that is, calculations, plans, process sheets, costs, □. (50% of the grade).
2. Presentation of the Work. After the delivery of the Final Work Report, the student will make a public presentation of it (20% of the grade).
3. At the end of the course, the student must take an evaluation exam of the different theoretical aspects developed during the course. (30% of the grade) Maintaining the minimum grade requirements set forth in the previous case

### SECOND CHANCE (June/July):

In the Second Opportunity all students will be evaluated following the guidelines established in the modality "b) Global evaluation" of the First Opportunity Ethical Commitment: The student is expected to present adequate ethical behavior, as stated in Articles 39, 40, 41 and 42 of the Regulation on the evaluation, qualification and quality of teaching and the learning process of the student body, approved in the Senate on April 18, 2023.

In the case of detecting unethical behavior (copying, plagiarism, use of unauthorized electrical devices, and others) it will be considered that the student does not meet the necessary requirements to pass the subject. In this case, the overall grade for this academic year will be fail (0.0).

NOTICE: In the event of discrepancies between the different language versions of the guide, what is included in the Spanish version will prevail.

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**Sources of information**

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**Basic Bibliography**

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**Complementary Bibliography**

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Tuhin Mukherjee, **Theory and Practice of Additive Manufacturing**, 978-1394202263, 1ª, John Wiley & Sons Inc, 2023

Jing Zhang, Yeon-Gil Jung, **Additive Manufacturing: Materials, Processes, Quantifications and Applications**, 9780128121559, 1ª, Elsevier, 2018

Martin Leary, **Design for Additive Manufacturing**, 9780128168875, 1, Elsevier, 2019

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**Recommendations**

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| IDENTIFYING DATA    |                                                                                                                                                                                                         |           |      |            |
|---------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|------|------------|
| Materials           |                                                                                                                                                                                                         |           |      |            |
| Subject             | Materiais                                                                                                                                                                                               |           |      |            |
| Code                | V04M196V01103                                                                                                                                                                                           |           |      |            |
| Study programme     | Máster Universitario en Fabricación Aditiva                                                                                                                                                             |           |      |            |
| Descriptors         | ECTS Credits                                                                                                                                                                                            | Choose    | Year | Quadmester |
|                     | 6                                                                                                                                                                                                       | Mandatory | 1    | 1c         |
| Teaching language   | Castelán                                                                                                                                                                                                |           |      |            |
| Department          |                                                                                                                                                                                                         |           |      |            |
| Coordinator         | Pérez Vázquez, María Consuelo                                                                                                                                                                           |           |      |            |
| Lecturers           | Álvarez González, David<br>Díaz Fernández, Belén<br>Pérez Vázquez, María Consuelo                                                                                                                       |           |      |            |
| E-mail              | mcperez@uvigo.es                                                                                                                                                                                        |           |      |            |
| Web                 | <a href="http://https://eei.uvigo.es/es/estudios/masteres-galicia-2030/master-en-fabricacion-aditiva/">http://https://eei.uvigo.es/es/estudios/masteres-galicia-2030/master-en-fabricacion-aditiva/</a> |           |      |            |
| General description | Descrición das principais familias de materiais empregados en FA xunto coas técnicas de caracterización mais utilizadas, tanto mecánicas, como químicas e físicas.                                      |           |      |            |

### Resultados de Formación e Aprendizaxe

|      |                                                                                                                                                                                                                       |
|------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Code |                                                                                                                                                                                                                       |
| B2   | Identificar as vantaxes da produción de obxectos por impresión 3D para avaliar o rendemento na súa fabricación.                                                                                                       |
| B4   | Definir os requisitos de calidade, seguridade e medio ambiente en contornas de fabricación aditiva para integralos no sistema de xestión de control da produción                                                      |
| C1   | Coñecer e aplicar técnicas de caracterización e análise de materiais (metais, cerámicas, composites, polímeros...) co obxectivo de comprender as súas propiedades e identificar usos potenciais.                      |
| C4   | Seleccionar materiais para aplicacións concretas de manufactura a partir das especificacións das ferramentas e impresoras de manufactura aditiva que empregar, así como dos diferentes tipos de modelados existentes. |

### Resultados previstos na materia

| Expected results from this subject                                                                                                                              | Training and Learning Results |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|
| Coñecer e seleccionar materiais para aplicacións concretas, definindo os requisitos de calidade aplicando as técnicas de caracterización e análise de materiais | B2<br>B4<br>C1<br>C4          |

### Contidos

| Topic                                    |                                                                                                                                                                                                                                                                                                                                                                           |
|------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Introdución aos materiais en FA.         | Importancia económica e social.                                                                                                                                                                                                                                                                                                                                           |
| Materiais metálicos: Aceiros             | Aceiros. Solidificación e transformación. Transformacións en estado sólido<br>Aceiros inoxidables.<br>Diagramas de fase binarios e terciarios.<br>Diagramas TTT e CCT.<br>Influencia dos parámetros de Fabricación.                                                                                                                                                       |
| Materiais metálicos: Aliaxes de Aluminio | Vantaxes e desvantaxes do aluminio. Clasificación das aliaxes de aluminio.<br>Aliaxes de aluminio para moldeado.<br>Principais aliaxes de aluminio en fabricación aditiva: aluminio-silicio, aluminio-magnesio-silicio, aluminio-zinc, aluminio-escandio.<br>Envellecemento de aliaxes de aluminio.                                                                       |
| Técnicas de post-procesado.              | Mecanizado. Shot peening.<br>Eliminación de tensións residuais.<br>Técnicas de recubrimento. Anodizado.                                                                                                                                                                                                                                                                   |
| Materiais Poliméricos                    | Introdución a materiais poliméricos, aplicacións e procesado.<br>Polímeros para impresión 3D. Propiedades de materiais poliméricos para técnicas de impresión 3D: FDM, SLS, SLA<br>Caracterización e selección de polímeros. Caracterización térmica: DSC, DMA, TGA. Control de calidade<br>Selección de materiais. Selección de materiais para aplicacións determinadas. |

|                                                             |                                                                                                                                                                                                                                                      |
|-------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Materiais cerámicos                                         | Cerámicas de enxeñaría. Cerámicas técnicas, características, aplicacións, técnicas de fabricación, postprocesado.<br>Materiais de construción. FA en construción, requisitos dos materiais, características do estado fresco e do estado endurecido. |
| Técnicas de análises e avaliación de propiedades.           | Ensaio destrutivos.<br>Ensaio de resistencia á corrosión.<br>Ensaio non destrutivos.<br>Control de calidade.<br>Inspección.                                                                                                                          |
| Requisitos de seguridade asociados a cada tipo de material. | Normas referidas aos requisitos de seguridade.<br>Manipulación de pos.                                                                                                                                                                               |
| Selección de materiais.                                     | Diagramas de selección de materiais<br>Índices de selección<br>Bases de datos                                                                                                                                                                        |

| Planificación                                        |             |                             |             |
|------------------------------------------------------|-------------|-----------------------------|-------------|
|                                                      | Class hours | Hours outside the classroom | Total hours |
| Actividades introductorias                           | 1           | 0                           | 1           |
| Lección maxistral                                    | 24          | 49                          | 73          |
| Prácticas de laboratorio                             | 14          | 15                          | 29          |
| Traballo tutelado                                    | 2           | 30                          | 32          |
| Estudo de casos                                      | 1           | 6                           | 7           |
| Foros de discusión                                   | 0           | 5                           | 5           |
| Exame de preguntas obxectivas                        | 1           | 0                           | 1           |
| Informe de prácticas, prácticum e prácticas externas | 1           | 0                           | 1           |
| Presentación                                         | 1           | 0                           | 1           |

\*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

| Metodoloxía docente        |                                                                                                                                                                 |
|----------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                            | Description                                                                                                                                                     |
| Actividades introductorias | Presentación da materia                                                                                                                                         |
| Lección maxistral          | Exposición por parte do profesor dos contidos teóricos e resolución de problemas tipo                                                                           |
| Prácticas de laboratorio   | Realización de ensaios, resolución de problemas e elaboración do informe correspondente                                                                         |
| Traballo tutelado          | Preparación dunha presentación sobre un tema proposto polo profesor. A elaboración desta presentación contará co apoio do profesor responsable desa actividade. |
| Estudo de casos            | Estudo de casos prácticos propostos polo profesor, relacionados coa materia para profundar nun aspecto determinado                                              |
| Foros de discusión         | Foro de discusión telemático                                                                                                                                    |

| Atención personalizada |                                                                            |
|------------------------|----------------------------------------------------------------------------|
| Methodologies          | Description                                                                |
| Lección maxistral      | O alumno/a terá atención personalizada no horario de titorías do profesor. |
| Traballo tutelado      | O alumno/a terá atención personalizada no horario de tutorías do profesor. |
| Estudo de casos        | O alumno/a terá atención personalizada no horario de tutorías do profesor. |

| Avaliación                                           |                                                      |               |                               |          |
|------------------------------------------------------|------------------------------------------------------|---------------|-------------------------------|----------|
|                                                      | Description                                          | Qualification | Training and Learning Results |          |
| Lección maxistral                                    | Preguntas obxectivas                                 | 30            | B2<br>B4                      | C1<br>C4 |
| Prácticas de laboratorio                             | Asistencia e participación. Avaliación dos contidos. | 25            |                               | C1<br>C4 |
| Traballo tutelado                                    | O traballo avaliarase segundo a rúbrica establecida. | 5             | B4                            |          |
| Estudo de casos                                      | Resolución dos casos expostos                        | 10            | B2                            |          |
| Informe de prácticas, prácticum e prácticas externas | Elaboración e entrega da memoria de prácticas.       | 15            | B4                            | C1       |
| Presentación                                         | Exposición e defensa do traballo tutelado.           | 15            | B4                            |          |

#### Other comments on the Evaluation

A opción preferente de avaliación será a avaliación continua seguindo o plan establecido nesta sección.

En caso de renuncia á avaliación continua (de acordo ás condicións e prazo indicados polo profesor responsable), o

alumnado poderá incorporarse ao sistema de avaliación global no que se fará un único exame na data proposta para o exame final e no que se incluírán todos os contidos da materia. No exame da segunda edición, avaliaráanse todos os contidos nun único exame cuxa valoración será do 100% e no que se incluírán todos os contidos.

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#### **Bibliografía. Fontes de información**

##### **Basic Bibliography**

Dutta, Bhaskar, **Science, technology and applications of metals in additive manufacturing**, 9780128166437, Elsevier, 2019

Li Yang, **Additive manufacturing of metals : the technology, materials, design and production**, 978-3-319-55127-2, Springer Berlin Heidelberg, 2017

Peter C. Powel, **Engineering with Polymers**, Chapman and Hall, 1983

Bandyopadhyay, Amit, and Susmita Bose, **Additive Manufacturing**, Boca Ratón: CRC Press, 2020

##### **Complementary Bibliography**

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#### **Recomendacións**

##### **Subjects that continue the syllabus**

Aplicacións en automoción/V04M196V01201

Aplicacións en Enxeñería biomédica/V04M196V01202

Taller/V04M196V01106

##### **Subjects that are recommended to be taken simultaneously**

Deseño e desenvolvemento do produto/V04M196V01101

Tecnoloxías de fabricación/V04M196V01102

| <b>IDENTIFYING DATA</b>                                               |                                                                                                                                                                                                                     |           |      |            |
|-----------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|------|------------|
| <b>Entrepreneurship, project management and intellectual property</b> |                                                                                                                                                                                                                     |           |      |            |
| Subject                                                               | Entrepreneurship, project management and intellectual property                                                                                                                                                      |           |      |            |
| Code                                                                  | V04M196V01104                                                                                                                                                                                                       |           |      |            |
| Study programme                                                       | Máster Universitario en Fabricación Aditiva                                                                                                                                                                         |           |      |            |
| Descriptors                                                           | ECTS Credits                                                                                                                                                                                                        | Choose    | Year | Quadmester |
|                                                                       | 3                                                                                                                                                                                                                   | Mandatory | 1st  | 1st        |
| Teaching language                                                     | #EnglishFriendly Spanish                                                                                                                                                                                            |           |      |            |
| Department                                                            |                                                                                                                                                                                                                     |           |      |            |
| Coordinator                                                           | Goicoechea Castaño, María Iciar                                                                                                                                                                                     |           |      |            |
| Lecturers                                                             | Goicoechea Castaño, María Iciar                                                                                                                                                                                     |           |      |            |
| E-mail                                                                | igoicoechea@uvigo.es                                                                                                                                                                                                |           |      |            |
| Web                                                                   |                                                                                                                                                                                                                     |           |      |            |
| General description                                                   | English Friendly subject: International students may request from the teachers:<br>a) resources and bibliographic references in English,<br>b) tutoring sessions in English,<br>c) exams and assessments in English |           |      |            |

### Training and Learning Results

|      |                                                                                                                                                                                                    |
|------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Code |                                                                                                                                                                                                    |
| C6   | To develop creativity and a spirit of innovation in order to respond to the challenges that arise in the processes and organization of work and personal life.                                     |
| D1   | Prepare technical and administrative documentation in accordance with current legislation and customer requirements. Comply with current legislation governing additive manufacturing regulations. |
| D2   | Evaluate the economic costs and business opportunities derived from the application of additive manufacturing in both production and R&D processes.                                                |

### Expected results from this subject

| Expected results from this subject                                                                                                                                                                                               | Training and Learning Results |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|
| RA17: Develop the creativity and the spirit of innovation to answer to the challenges that present in the processes and in the organisation of the work and of the personal life                                                 | C6                            |
| RA22: Elaborate technical and administrative documentation in accordance with the valid legislation and with the requests of the customer. Fulfil with the valid legislation that regulates the rule of the additive manufacture | D1                            |
| RA23: Evaluate the economic cost and the opportunities of business derived of the application of the additive manufacture so much in the processes of production as in the ones of R&D                                           | D2                            |

### Contents

| Topic                                                                           |                                                                                                                                                                                                                                    |
|---------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. Entrepreneurship                                                             | 1.1 Definition<br>1.2 Tools for the entrepreneurship: Design thinking and lean start up                                                                                                                                            |
| 2. Project management                                                           | 2.1 Predictive Methodologies and agile<br>2.2 Cycle life of the project and cycle of life of the product                                                                                                                           |
| 3. Phase of Beginning: utilisation of agile methodologies for managing projects | 3.1 Business Model Canvas<br>3.2 Project Model Canvas<br>3.3 Project charter                                                                                                                                                       |
| 4. Phase Planning of the Project                                                | 4.1 Work breakdown structure (WBS)<br>4.2 Planning of the project with computer tool.<br>4.2.1 Method of the critical path<br>4.2.2 Allocation of resource.<br>4.2.3 Allocation costs<br>4-2-4 Creation of Baseline of the Project |
| 5. Phase Executing and controlling of the Project                               | 5.1 Tracking Gantt. Status date<br>5.2 Update of projects<br>5.3 Methodology of earned value                                                                                                                                       |
| 6. Phase of ending                                                              | 6.1 Final deliverable<br>6.2 Lessons learned                                                                                                                                                                                       |

**Planning**

|                       | Class hours | Hours outside the classroom | Total hours |
|-----------------------|-------------|-----------------------------|-------------|
| Lecturing             | 10          | 23                          | 33          |
| Practices through ICT | 8           | 15                          | 23          |
| Seminars              | 6           | 3                           | 9           |
| Mentored work         | 1           | 9                           | 10          |

\*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

**Methodologies**

|                       | Description                                                                                                                                                                                                                                                                                                                                                                                   |
|-----------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Lecturing             | Exhibition by part of the teachers of the contents on the matter object of study, theoretical bases and/or guidelines of a work, exercise or project to develop by the student. The theoretical contents will go presenting by the teachers, complemented with the active intervention of the students, in total coordination with in the development of the practical activities programmed. |
| Practices through ICT | Practical classes in which the students works the computer classrooms with software of planning                                                                                                                                                                                                                                                                                               |
| Seminars              | Conferences given by companies devoted to the additive manufacture                                                                                                                                                                                                                                                                                                                            |
| Mentored work         | Work to make during the course                                                                                                                                                                                                                                                                                                                                                                |

**Personalized assistance**

| Methodologies         | Description                                                      |
|-----------------------|------------------------------------------------------------------|
| Practices through ICT | Personalised attention to the students in the computer practices |
| Mentored work         | Follow-up of the work along the course through tutorial classes  |

**Assessment**

|                       | Description                                                                                                                                                                                                                                                                                                                                                                                                                                          | Qualification | Training and Learning Results |
|-----------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|-------------------------------|
| Lecturing             | Exhibition of theoretical appearances by part of the teacher. The students will have an examination to value the theoretical contents learnt.<br>Results of learning:<br>Elaborate technical and administrative documentation in accordance with the valid legislation and with the requests of the customer. Fulfil with the valid legislation that regulates the rule of the additive manufacture.                                                 | 40            | D1                            |
| Practices through ICT | They will make practices of management of projects with software of planning. The students has to make the reports of practices (deliverables) of each one of them, and deliver them in to the platform Moovi in the distinguished dates<br>Resulted learning:<br>Evaluate the economic costs and the opportunities of business derived of the application of the additive manufacture so much in the processes of production as in the ones of R&D. | 30            | D2                            |
| Mentored work         | Work to make by the students along the course<br>Resulted learning:<br>Develop the creativity and the spirit of innovation to answer to the challenges that present in the processes and in the organisation of the work and of the personal life                                                                                                                                                                                                    | 30            | C6                            |

**Other comments on the Evaluation**

All the students can access to the continuous assesment of the matter along the course. Once happened a month from the start of the course, the students can communicate by writing to the teacher his renunciation to the continuous assesment and opt to the global assesment. The qualification of the continuous assesment is as the following:

- Reports of practices (deliverables) carried out throughout the course will have a value of 30% in the final grade.
- The written test has a value of 40% in the final grade.
- the menotored work will have a value of 30% in the final grade.

To be able to pass the continuous assessment, each part must be passed with a minimum of 3.5 points.

Students who opt for global evaluation will take the final exam on the corresponding date set by the school's management.

The exam will cover both theoretical class content and practical content.

The official exam calendar will be published on the school's official website. <http://eei.uvigo.es/>

Ethical commitment: Students are expected to present appropriate ethical behavior. In case of detecting unethical behavior (copying, plagiarism, use of unauthorized electronic devices, and others), it is considered that the student does not meet the necessary requirements to pass the subject. In this case, the global grade for the current academic year will be a fail (0.0).

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#### Sources of information

##### Basic Bibliography

Manuel Fernandez Iglesias y otros, **Design Thinking. Guía de iniciación**, 978-8481588460, 1, Servicio publicaciones Universidad de Vigo, 2020

Project management Institute (PMI), **A guide to the Project Management Body of Knowledge (PMBok Guide)**, 978-1628256796, 1, PMI, 2021

Lewis, Cindy, **Step by Step. MICROSOFT PROJECT 2019**, 978-1-5093-0742-5, 1, pearson education, 2019

##### Complementary Bibliography

Buchtik, Liliana, **Secrets to Mastering the WBS in real world projects**, 978-9974987913, 1, PMI, 2013

Ramon Rubio, **INTRODUCCIÓN A LA FABRICACIÓN ADITIVA EN LA INDUSTRIA**, 978-8417701970, 1, Fundación Confemetal, 2021

Eric Rie, **El método Lean Startup : cómo crear empresas de éxito utilizando la innovación continua**, 978-8423409495, 11, Barcelona : Deusto, 2017

Alonso Alvarez garcia, **Métodos ágiles y scrum**, 978-8441531048, 1, Anaya multimedia, 2012

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#### Recommendations

| IDENTIFYING DATA                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |           |      |            |
|------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|------|------------|
| Integración con outras tecnoloxías |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |           |      |            |
| Subject                            | Integración con outras tecnoloxías                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |           |      |            |
| Code                               | V04M196V01105                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |           |      |            |
| Study programme                    | Máster Universitario en Fabricación Aditiva                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |           |      |            |
| Descriptors                        | ECTS Credits                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Choose    | Year | Quadmester |
|                                    | 3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Mandatory | 1    | 1c         |
| Teaching language                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |           |      |            |
| Department                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |           |      |            |
| Coordinator                        | Paz Domonte, Enrique                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |           |      |            |
| Lecturers                          | Armesto Quiroga, José Ignacio<br>Díaz-Cacho Medina, Miguel Ramón<br>Paz Domonte, Enrique                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |           |      |            |
| E-mail                             | epaz@uvigo.es                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |           |      |            |
| Web                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |           |      |            |
| General description                | (*)La presente asignatura tiene como principal objetivo el que los alumnos aprendan cómo integrar diferentes tecnologías dentro de los procesos de fabricación. Se prestará una atención especial a la integración de los sistemas de fabricación en los sistemas de control de producción, calidad y medio ambiente de las empresas. Se pretende que los alumnos entiendan como introducir en los sistemas de fabricación aditiva, diversas variables ya sean necesarias en el propio proceso de fabricación (por ejemplo, mediciones de distancia) como variables independientes (por ejemplo, variables climatológicas). |           |      |            |

| Resultados de Formación e Aprendizaxe |                                                                                                                                                                      |
|---------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Code                                  |                                                                                                                                                                      |
| D4                                    | Combinar e integrar diferentes tecnoloxías nos procesos de fabricación aditiva                                                                                       |
| D8                                    | Integrar o sistema de fabricación aditiva no sistema de xestión de control da produción da empresa, atendendo a requisitos de calidade, seguridade e medio ambiente. |

| Resultados previstos na materia                                                                                                                                                                           |                               |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|
| Expected results from this subject                                                                                                                                                                        | Training and Learning Results |
| Capacidade para combinar e integrar diferentes tecnoloxías nos procesos de fabricación aditiva. □ Saber, Saber facer                                                                                      | D4                            |
| Capacidade para integrar o sistema de fabricación aditiva no sistema de xestión de control da produción da empresa, atendendo a requisitos de calidade, seguridade e medio ambiente. □ Saber, Saber facer | D8                            |

| Contidos                                                                                    |                                                                                                                  |
|---------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------|
| Topic                                                                                       |                                                                                                                  |
| Descrición das novas tecnoloxías emerxentes e a súa aplicación na FA.                       | Descrición dos sensores/recolectores e actuadores xunto cos seus circuitos típicos de acondicionamento de sinal. |
| Aspectos e nocións básicas sobre a integración de tecnoloxías.                              | Aplicacións de integración de sistemas; adquisición e distribución de datos.                                     |
| Hardware e software de proceso. Interoperabilidade (capacidade para compartir información). | Explicación dos distintos tipos de impresoras 3D, as topoloxías básicas e a súa construción.                     |

| Planificación                 |             |                             |             |
|-------------------------------|-------------|-----------------------------|-------------|
|                               | Class hours | Hours outside the classroom | Total hours |
| Lección maxistral             | 16          | 15                          | 31          |
| Prácticas de laboratorio      | 8           | 8                           | 16          |
| Traballo tutelado             | 2           | 15                          | 17          |
| Exame de preguntas obxectivas | 1           | 10                          | 11          |

\*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

| Metodoloxía docente |             |
|---------------------|-------------|
|                     | Description |

|                          |                                                                                                                                                                                                                                                                                                                                                                                                                |
|--------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Lección maxistral        | Exposición oral complementada co uso de medios audiovisuales e a introdución dalgunhas preguntas dirixidas aos estudantes, coa finalidade de transmitir coñecementos e facilitar a aprendizaxe. A orde dos temas impartidos non terá que ser o descrito na guía docente. Ademais, haberá temas que se poidan ver conjuntamente no desenvolvemento doutros, xa que a división entre eles pode non ser estricta. |
| Prácticas de laboratorio | Realización de prácticas de laboratorio na medida do posible; ou, no seu defecto, a resolución de exercicios e problemas concretos na aula, a partir dos coñecementos explicados.                                                                                                                                                                                                                              |
| Traballo tutelado        | Realización dun boletín de problemas de carácter individual, con exercicios similares aos resoltos no aula. Ademais, dentro dos traballos tutelados podrase incluír algún pequeno traballo de temas concretos da asignatura pra asegurar a correcta comprensión da materia.                                                                                                                                    |

#### Atención personalizada

| Methodologies            | Description                                                                                                                  |
|--------------------------|------------------------------------------------------------------------------------------------------------------------------|
| Lección maxistral        | O alumno dispón das correspondentes sesións de tutorías personalizadas, para a resolución das dúbidas que xurdan da materia. |
| Prácticas de laboratorio | O alumno dispón das correspondentes sesións de tutorías personalizadas, para a resolución das dúbidas que xurdan da materia. |
| Traballo tutelado        | O alumno dispón das correspondentes sesións de tutorías personalizadas, para a resolución das dúbidas que xurdan da materia. |

#### Avaliación

|                               | Description                                                                              | Qualification | Training and Learning Results |
|-------------------------------|------------------------------------------------------------------------------------------|---------------|-------------------------------|
| Prácticas de laboratorio      | (*)Realización de las tareas establecidas en la materia, en el marco de esta metodología | 30            | D4<br>D8                      |
| Traballo tutelado             | (*)Realización de un trabajo individual o en grupo, así como su exposición en clase      | 40            | D4<br>D8                      |
| Exame de preguntas obxectivas | (*)Examen                                                                                | 30            | D4<br>D8                      |

#### Other comments on the Evaluation

No marco das "Prácticas de laboratorio" poderanse incluír aspectos tales coma a asistencia a clase, traballo persoal, actitude, etc., para axudar á obtención do aprobado. Os alumnos con recoñecemento de dedicación a tempo parcial e dispensa académica de exención de asistencia, serán avaliados da mesma forma, permitindo unha semana máis de marxe nas entregas de tarefas. Para a segunda oportunidade non haberá un segundo prazo de entrega de traballos, e a avaliación relativa a "Obradoiro" e "Prácticas de laboratorio" incluírase na "Proba mixta". Os criterios de avaliación da convocatoria adiantada de decembro serán iguais ós da segunda oportunidade do curso anterior.

#### Bibliografía. Fontes de información

##### Basic Bibliography

##### Complementary Bibliography

#### Recomendacións



| IDENTIFYING DATA    |                                                                                                                                          |           |      |            |
|---------------------|------------------------------------------------------------------------------------------------------------------------------------------|-----------|------|------------|
| <b>Workshop</b>     |                                                                                                                                          |           |      |            |
| Subject             | Workshop                                                                                                                                 |           |      |            |
| Code                | V04M196V01106                                                                                                                            |           |      |            |
| Study programme     | Máster Universitario en Fabricación Aditiva                                                                                              |           |      |            |
| Descriptors         | ECTS Credits                                                                                                                             | Choose    | Year | Quadmester |
|                     | 6                                                                                                                                        | Mandatory | 1st  | 1st        |
| Teaching language   | #EnglishFriendly<br>Spanish                                                                                                              |           |      |            |
| Department          |                                                                                                                                          |           |      |            |
| Coordinator         | Pereira Domínguez, Alejandro                                                                                                             |           |      |            |
| Lecturers           | Cabeza Simo, Marta María<br>Carou Porto, Diego<br>Cerqueiro Pequeño, Jorge<br>Collazo Fernández, Antonio<br>Pereira Domínguez, Alejandro |           |      |            |
| E-mail              | apereira@uvigo.es                                                                                                                        |           |      |            |
| Web                 |                                                                                                                                          |           |      |            |
| General description |                                                                                                                                          |           |      |            |

| Training and Learning Results |                                                                                                                                                                                                                                                                                                                |
|-------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Code                          |                                                                                                                                                                                                                                                                                                                |
| B5                            | Identify the characteristics of objects manufactured by 3D printing through the study of their structure and functions.                                                                                                                                                                                        |
| C3                            | Identify opportunities for the creation of new designs from the possibilities offered by the new design and printing techniques of additive manufacturing.                                                                                                                                                     |
| C5                            | Solve situations, problems or contingencies with initiative and autonomy in the field of their competence, with creativity, innovation and a spirit of improvement in their personal work and in their with creativity, innovation and spirit of improvement in personal work and in that of the team members. |
| C6                            | To develop creativity and a spirit of innovation in order to respond to the challenges that arise in the processes and organization of work and personal life.                                                                                                                                                 |
| C7                            | Analyze the characteristics of the objects to be produced in order to select the most suitable printing method.                                                                                                                                                                                                |
| C8                            | Manufacture objects and elements through 3D printing by applying reverse engineering techniques to improve production processes.                                                                                                                                                                               |
| 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                                                                                                                                 |
| D10                           | Evaluar y aplicar los procedimientos para la evaluación de la seguridad, durabilidad y ciclo de vida de los materiales.                                                                                                                                                                                        |
| D11                           | Supervisar y aplicar procedimientos de gestión de calidad, de accesibilidad universal y de «diseño para todas las personas», en las actividades profesionales incluidas en los procesos de producción o prestación de servicios.                                                                               |

| Expected results from this subject |                               |
|------------------------------------|-------------------------------|
| Expected results from this subject | Training and Learning Results |
| Knowledges                         | B5                            |
| Skills                             | C3                            |
|                                    | C5                            |
|                                    | C6                            |
|                                    | C7                            |
|                                    | C8                            |
| Competitions                       | D9                            |
|                                    | D10                           |
|                                    | D11                           |

| Contents                        |                                                                                                                                                                                           |
|---------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Topic                           |                                                                                                                                                                                           |
| Introduction Methodology        | Application and exhibition *dee works proposed                                                                                                                                            |
| Design for additive manufacture | They will obtain conceptual designs and designs detailed                                                                                                                                  |
| Selection of materials          | Study of agreement to requests of materials to employ                                                                                                                                     |
| Manufacture of Works proposed   | Study of orientations and necessary supports. Generation of code necessary G<br>In function of resources application of distinct technologies<br>dimensional and geometrical Measurements |

| <b>Planning</b>              |             |                             |             |
|------------------------------|-------------|-----------------------------|-------------|
|                              | Class hours | Hours outside the classroom | Total hours |
| Presentation                 | 1           | 0                           | 1           |
| Research based methodologies | 12          | 0                           | 12          |
| Project based learning       | 25          | 70                          | 95          |
| Workshops                    | 12          | 24                          | 36          |
| Presentation                 | 3           | 0                           | 3           |
| Project                      | 3           | 0                           | 3           |

\*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

| <b>Methodologies</b>         |                                                            |
|------------------------------|------------------------------------------------------------|
|                              | Description                                                |
| Presentation                 | Exhibition of methodology of course<br>Exhibition of works |
| Research based methodologies | Development of product for essays                          |
| Project based learning       | Development of product tooling                             |
| Workshops                    | Development of skills in laboratories                      |

| <b>Personalized assistance</b> |             |
|--------------------------------|-------------|
| Methodologies                  | Description |
| Presentation                   |             |
| Research based methodologies   |             |
| Project based learning         |             |
| Workshops                      |             |
| Tests                          | Description |
| Presentation                   |             |
| Project                        |             |

| <b>Assessment</b> |                                                                                                                                                                                                                                                              |               |                               |
|-------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|-------------------------------|
|                   | Description                                                                                                                                                                                                                                                  | Qualification | Training and Learning Results |
| Workshops         | (*)Desarrollo de diseño de producto e proceso.<br>Se ten en conta<br>Dificultad diseño<br>Grado de innovación<br>Realizacion Planificacion proceso<br>Realización programación CAM necesaria según diseño<br>Grado e dificultade de fabricación<br>Execución | 40            |                               |
| Presentation      | (*)en 10 -15 ' debese presentar expoñer Obxectivos desenrrolo e metodologxa, Cálculos, Resultados e Conclusions                                                                                                                                              | 20            |                               |
| Project           | (*)Adocumentación técnica debese entregar conxuntamente co prototipo físico que incluíra unha memoria, presuposto e planos                                                                                                                                   | 40            |                               |

### Other comments on the Evaluation

**Sources of information**

**Basic Bibliography**

**Complementary Bibliography**

Bandyopadhyay, A & Bose, S., **Additive manufacturing**, 13: 978-1-4822-2360-6, CRC Press Taylor & Francis Group, 2015

Kumar, S., **Additive manufacturing processes**, <https://doi.org/10.1007/978-3-030-45089-2>, 2020

Leach, R., & Carmignato, S, **Precision Metal Additive Manufacturing**, <https://doi.org/10.1201/9780429436543>, CRC, 2020

Pou, Juan., Riveiro, Antonio., & Davim, J. Paulo, **Additive manufacturing**, 978-0-12-818411-0, Elsevier, 2021

**Recommendations**

| IDENTIFYING DATA          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |          |      |            |
|---------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|------|------------|
| Aplicacións en automoción |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |          |      |            |
| Subject                   | Aplicacións en automoción                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |          |      |            |
| Code                      | V04M196V01201                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |          |      |            |
| Study programme           | Máster Universitario en Fabricación Aditiva                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |          |      |            |
| Descriptors               | ECTS Credits                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Choose   | Year | Quadmester |
|                           | 6                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Optional | 1    | 2c         |
| Teaching language         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |          |      |            |
| Department                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |          |      |            |
| Coordinator               | Collazo Fernández, Antonio                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |          |      |            |
| Lecturers                 | Casarejos Ruiz, Enrique<br>Collazo Fernández, Antonio<br>Figueroa Martínez, Raúl<br>Peláez Lourido, Gustavo Carlos<br>Prado Cerqueira, María Teresa<br>Segade Robleda, Abraham                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |          |      |            |
| E-mail                    | acollazo@uvigo.es                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |          |      |            |
| Web                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |          |      |            |
| General description       | <p>Esta materia optativa está deseñada para proporcionar ao estudante os coñecementos e habilidades necesarios para aproveitar os beneficios da fabricación aditiva en proxectos de fabricación asociados ao sector da automoción. Contémplase unha visión integral do proceso de implementación do proxecto, analizando as tecnoloxías de fabricación aplicables, os materiais dispoñibles, os criterios económicos, de calidade, seguridade e respecto ao medio ambiente.</p> <p>A través de casos de estudo e exemplos prácticos analizaranse diversas aplicacións, estudando como se utilizan as diversas tecnoloxías de FA en prototipado, fabricación de ferramentas e utillaxes, mantemento, produción de compoñentes personalizados, pezas de alto rendemento e preseries e produción en serie.</p> |          |      |            |

### Resultados de Formación e Aprendizaxe

|      |                                                                                                                                                                                                                       |
|------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Code |                                                                                                                                                                                                                       |
| B9   | Definir o método de impresión 3D tendo en conta as características do obxecto que se vai a producir                                                                                                                   |
| B11  | Recoñecer as posibilidades da fabricación aditiva fronte á fabricación tradicional.                                                                                                                                   |
| C1   | Coñecer e aplicar técnicas de caracterización e análise de materiais (metais, cerámicas, composites, polímeros...) co obxectivo de comprender as súas propiedades e identificar usos potenciais.                      |
| C4   | Seleccionar materiais para aplicacións concretas de manufactura a partir das especificacións das ferramentas e impresoras de manufactura aditiva que empregar, así como dos diferentes tipos de modelados existentes. |
| C9   | Reparar pezas de alto valor engadido e producir pezas de substitución a través do emprego de ferramentas e tecnoloxías de fabricación aditiva                                                                         |

### Resultados previstos na materia

|                                    |                               |
|------------------------------------|-------------------------------|
| Expected results from this subject | Training and Learning Results |
| Coñecementos                       | B9<br>B11                     |
| Habilidades                        | C1<br>C4<br>C9                |

### Contidos

|                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|--------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Topic                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| Tema 1. Introducción á fabricación aditiva no sector de automoción | Evolución histórica da fabricación aditiva no sector. Principais beneficios. Implantación industrial da FA no sector do automóbil.                                                                                                                                                                                                                                                                                                                                                                                                    |
| Tema 2. Tecnoloxías de Fabricación aditiva aplicadas na automoción | <p>Principais tecnoloxías de fabricación con materiais poliméricos no sector.</p> <p>Extrusión de material (FDM)</p> <p>Fotopolimerización en tanque ou cuba (SLA)</p> <p>Fusión en leito de po (SLS)</p> <p>Inxección de aglutinante. Tecnoloxía HP Multi Jet Fusion.</p> <p>Principais tecnoloxías de fabricación aditiva de metal no sector.</p> <p>Deposición de enerxía localizada (DED): DED-L e DED-Arc</p> <p>Fusión de leito de po EBM</p> <p>Outras tecnoloxías emerxentes.</p> <p>Fabricación multimaterial e híbrida.</p> |

|                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|-----------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Tema 3. Modelado e simulación numérica en fabricación aditiva. Sector automoción. | <p>Importancia da simulación numérica.<br/> Bases de cálculo FEM e optimización topolóxica.<br/> Preprocesado:<br/> Preparación de xeometría para FEM<br/> Condicións de contorno e aplicación de cargas.<br/> Modelos de material.<br/> Postprocesado:<br/> Análise de tensións e deformacións enfocado a ensaios estáticos.<br/> Análise estrutural, criterios de fallo.<br/> Optimización topolóxica.</p>                      |
| Tema 4. Aplicacións da FA na industria automotriz.                                | <p>Prototipado rápido e validación de deseños.<br/> Fabricación de ferramentas e utillaxes.<br/> Aplicacións de fabricación aditiva directa e indirecta no sector.<br/> Fabricación aditiva en mantemento.<br/> Produción de compoñentes personalizados e de baixo volume.<br/> Fabricación de pezas de alto rendemento<br/> Preseries e produción en serie.</p>                                                                  |
| Tema 5. Monitorización e aseguramento da calidade                                 | <p>Análise do efecto dos parámetros de impresión sobre as propiedades do produto.<br/> Postprocesamiento e acabado de pezas impresas.<br/> Monitorización e aseguramento de calidade</p>                                                                                                                                                                                                                                          |
| Tema 6. Casos de estudo                                                           | <p>Taller de fabricación aditiva<br/> Selección de materiais para aplicacións automotrices.<br/> Casos de estudo e exemplos prácticos de simulación numérica no sector da automoción<br/> Cálculo da peza sen optimizar.<br/> Optimización topolóxica e re-avaliación da peza optimizada.<br/> Demostracións prácticas de simulación numérica.<br/> Comparación das propiedades simuladas e experimentais das pezas impresas.</p> |
| Tema 7. Tendencias da fabricación aditiva na automoción                           | <p>Avances tecnolóxicos e novas aplicacións potenciais. Principais desafíos do sector.</p>                                                                                                                                                                                                                                                                                                                                        |

## Planificación

|                   | Class hours | Hours outside the classroom | Total hours |
|-------------------|-------------|-----------------------------|-------------|
| Lección maxistral | 16.5        | 28.5                        | 45          |
| Traballo tutelado | 11          | 49                          | 60          |
| Estudo de casos   | 22.5        | 22.5                        | 45          |

\*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

## Metodoloxía docente

|                   | Description                                                                                                                                                                                                                                                                                                                                                                                             |
|-------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Lección maxistral | Na sesión maxistral o profesorado, exporá na aula os principais conceptos de cada tema dos que consta a materia. Para isto apoiarase nos medios técnicos dispoñibles: presentacións en powerpoint, videos, etc.                                                                                                                                                                                         |
| Traballo tutelado | Coma parte avaliable da materia, o alumnado fará un ou dous traballos. A idea é que o/a estudante correlacione os conceptos vistos na materia de forma práctica nun suposto real, que aprenda a consultar fontes bibliográficas especializadas, que aprenda a traballar en grupo, linguaxe técnica, linguaxe inclusiva, etc. Ao final da materia, se fará unha breve exposición oral ao resto da clase. |
| Estudo de casos   | Preténdese enfrontar aos estudantes a situacións vinculadas co exercicio profesional. Os casos presentados desafían ou convidan o estudante á reflexión, á procura de alternativas de acción e á integración de distintos criterios para a toma de decisións.                                                                                                                                           |

## Atención personalizada

| Methodologies     | Description                                                                                                                    |
|-------------------|--------------------------------------------------------------------------------------------------------------------------------|
| Lección maxistral | Tempo reservado para atender e resolver as dúbidas dos alumnos.                                                                |
| Traballo tutelado | Orientación no desenvolvemento do traballo individual/grupo.                                                                   |
| Estudo de casos   | Orientación no proceso de aprendizaxe do alumno en relación aos casos expostos, guía para a procura de alternativas de acción. |

## Avaliación

| Description       |                                                                                                                                                                                                                                                                                                                                                                                                                                           | Qualification Training and Learning Results |           |                |
|-------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------|-----------|----------------|
| Lección maxistral | Realizarase mediante unha proba escrita (preguntas curtas, tipo test ou exercicios) que recollan os coñecementos adquiridos polo alumno ao longo do curso.                                                                                                                                                                                                                                                                                | 30                                          | B9<br>B11 | C1<br>C4<br>C9 |
| Traballo tutelado | Valorarase a calidade da memoria presentada. Durante a exposición, demostrarán o coñecemento adquirido e a súa capacidade de comunicación ao explicar de maneira clara e concisa os aspectos relevantes do seu traballo. Realizaranse preguntas relacionadas co tema, ás cales deberán responder de forma precisa e fundamentada, demostrando a súa comprensión profunda do tema e a súa capacidade para aplicar os conceptos aprendidos. | 40                                          | B9<br>B11 | C1<br>C4<br>C9 |
| Estudo de casos   | Valorarase a calidade dos resultados obtidos, as alternativas de acción e a integración dos distintos criterios para a toma de decisións                                                                                                                                                                                                                                                                                                  | 30                                          | B9<br>B11 | C1<br>C4<br>C9 |

### Other comments on the Evaluation

#### Primeira edición da Acta. Avaliación continua:

A avaliación continua realizarase durante o período de impartición da materia. A nota final da primeira edición será a suma das notas obtidas no conxunto das probas de avaliación. Para superar a materia será necesario alcanzar un mínimo do 40% na parte correspondente a Modelado e simulación numérica en fabricación aditiva (Temas 3 y 6)

Primeira edición da Acta. Renuncia á avaliación continua:

Aqueles alumnos que non se acollan á avaliación continua serán avaliados cun exame final sobre os contidos da totalidade da materia, que supoñerá o 100% da nota.

Exame de Julio (2ª Edición)

No exame de xullo non se terá en conta a avaliación continua. Poderase obter o 100% da cualificación no exame que se realizará na data previamente fixada polo centro. .

**COMPORTAMENTO ÉTICO DO ALUMNO:** Espérase que o alumno presente un comportamento ético adecuado e conforme á normativa recentemente aprobada (18 de abril de 2023) pola Universidade de Vigo, que se concreta no TÍTULO VII. DO USO DE MEDIOS ILÍCITOS, do REGULAMENTO SOBRE A AVALIACIÓN, A CUALIFICACIÓN E A CALIDADE DÁ DOCENCIA E DO PROCESO DE APRENDIZAXE DO ESTUDANTADO.

### Bibliografía. Fontes de información

#### Basic Bibliography

#### Complementary Bibliography

Bandyopadhyay, A & Bose, S., **Additive manufacturing**, 13: 978-1-4822-2360-6, CRC Press Taylor & Francis Group,, 2015

Leach, R., & Carmignato, S, **Precision Metal Additive Manufacturing**, <https://doi.org/10.1201/9780429436543>, 2020

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

Patrice Peyre, Eric Charkaluk, **Additive Manufacturing of Metal Alloys 1: Processes, Raw Materials and Numerical Simulation**, 10.1002/9781394163380, 2022

Zafar Alam, Faiz Iqbal, Dilshad Ahmad Khan, **Zafar Alam, Faiz Iqbal, Dilshad Ahmad Khan - Post-processing Techniques for Additive Manufacturing**, CRC Press, 2023

### Recomendacións

#### Subjects that continue the syllabus

Prácticas externas/V04M196V01205

Traballo Fin de Máster/V04M196V01206

#### Subjects that are recommended to be taken simultaneously

Aplicacións en Enxeñaría biomédica/V04M196V01202

### Other comments

Recomendase que o alumnado teña superado o teña cursado, todas as materias do primeiro cuadrimestre, antes de cursar esta materia.

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| <b>IDENTIFYING DATA</b>                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |          |      |            |
|-----------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|------|------------|
| <b>Applications in Biomedical Engineering</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |          |      |            |
| 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<br>Spanish<br>Galician                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |          |      |            |
| Department                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |          |      |            |
| Coordinator                                   | Pena Uris, Gloria María                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |          |      |            |
| Lecturers                                     | Casarejos Ruiz, Enrique<br>Feijó Vázquez, Iria<br>Hernández Martín, Primo<br>Pena Uris, Gloria María<br>Segade Robleda, Abraham                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |          |      |            |
| E-mail                                        | gpena@uvigo.gal                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |          |      |            |
| Web                                           | <a href="http://https://moovi.uvigo.gal/">http://https://moovi.uvigo.gal/</a>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |          |      |            |
| General description                           | <p>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.</p> <p>Finally, the techniques for verifying the quality of the manufactured part (metrology, microstructural, mechanical and durability characterization) are addressed.</p> <p>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.</p> |          |      |            |

### 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<br>B7<br>B9<br>B11         |
| New                                | C1<br>C4<br>C7                |
| New                                | D7<br>D9                      |



| <b>Contents</b>                                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|-------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Topic                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| 1. Introduction to additive manufacturing in the biomedical sector.                 | <ul style="list-style-type: none"> <li>□ Historical evolution of additive manufacturing (AM) in the biomedical sector.</li> <li>□ Benefits of AM: time and cost reduction, weight lightening, ergonomic improvements, personalised medicine.</li> <li>□ Applications of AM to biomedical products: prostheses, orthoses, pre-operative models and tooling.</li> <li>□ Ethical and legal aspects related to AM in the biomedical field.</li> </ul>                                                                                                                                                         |
| 2. Numerical modelling and simulation in additive manufacturing. Biomedical sector. | <ul style="list-style-type: none"> <li>□ Importance of numerical simulation.</li> <li>□ FEM calculation bases and topological optimisation.</li> <li>□ Preprocessing: <ul style="list-style-type: none"> <li>- Preparation of geometry for FEM.</li> <li>- Boundary conditions and application of loads.</li> <li>- Material models.</li> </ul> </li> <li>□ Post-processing in modelling: <ul style="list-style-type: none"> <li>- Stress and strain analysis with focus on static testing.</li> <li>- Structural analysis, failure criteria.</li> <li>- Topological optimisation.</li> </ul> </li> </ul> |
| 3. Biomaterials for Additive Manufacturing                                          | <ul style="list-style-type: none"> <li>□ General characteristics of biomaterials. Classification.</li> <li>□ Ceramics: HA, tricalcium phosphate (TCP). Other calcium phosphates (CaPs). Bioglass. Ceramic composites.</li> <li>□ Metallics: Noble metals, Ti6Al4V, TiNi. 316L, Co-Cr, CoCrMo. Mg alloys. Metal matrix composites.</li> <li>□ Polymers: natural biopolymers. Synthetic biopolymers. Polymer-ceramic composites.</li> <li>□ Advanced biomaterials for AF.</li> </ul>                                                                                                                        |
| 4. Additive manufacturing (AF) technologies applied to biomedical products.         | <ul style="list-style-type: none"> <li>□ Fused deposition modeling (FDM)</li> <li>□ Tank or vat light curing (SLA)</li> <li>□ Powder bed fusion (SLS)</li> <li>□ Binder injection (BJ)</li> <li>□ Localized energy deposition (DED)</li> <li>□ Electron beam melting (EBM)</li> <li>□ Multi-material manufacturing</li> <li>□ Bioprinting</li> </ul>                                                                                                                                                                                                                                                      |
| 5. Product quality control. Post-processing.                                        | <ul style="list-style-type: none"> <li>□ Analysis of the effect of printing parameters on product properties.</li> <li>□ Post-processing and surface treatments of parts.</li> <li>□ Structural, mechanical, thermal and chemical characterization. Related regulations and standards.</li> </ul>                                                                                                                                                                                                                                                                                                         |
| 6. Design and manufacturing project                                                 | <ul style="list-style-type: none"> <li>□ Study cases</li> <li>□ Initial design: particular conditioning factors. Topological optimization</li> <li>□ Initial printing tests: Influence of deposition parameters on properties.</li> <li>□ Manufacture of parts.</li> <li>□ Analysis of the results obtained. Lessons learned</li> </ul>                                                                                                                                                                                                                                                                   |

| <b>Planning</b>                                       |             |                             |             |
|-------------------------------------------------------|-------------|-----------------------------|-------------|
|                                                       | 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.

| <b>Methodologies</b>    |                                                                                                                                                                                                                                                                                                                                       |
|-------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                         | Description                                                                                                                                                                                                                                                                                                                           |
| Introductory activities | <p>The teaching staff present the course: contents, organisation, methodologies used, timetable and evaluation system.</p> <p>A description of the projects to be developed by the students is given, as well as the conditions for carrying them out.</p> <p>The tutoring and support system available to students is explained.</p> |

|                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|-----------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 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 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 mentored 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 efficiently 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 C1<br>B9<br>B11             |
| 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 C1<br>B7 C4<br>B9 C7<br>B11 |
| 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 C1<br>B9<br>B11             |

|              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |    |                      |
|--------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|----------------------|
| 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.<br>This presentation and defence will be evaluated according to a previously published rubric. | 40 | C1 D7<br>C4 D9<br>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 practitioner**, 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 Andreass, 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

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## 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

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## Other comments

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

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| IDENTIFYING DATA                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |          |      |            |
|-------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|------|------------|
| Aplicacións en enerxía e sustentabilidade |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |          |      |            |
| Subject                                   | Aplicacións en enerxía e sustentabilidade                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |          |      |            |
| Code                                      | V04M196V01203                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |          |      |            |
| Study programme                           | Máster Universitario en Fabricación Aditiva                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |          |      |            |
| Descriptors                               | ECTS Credits                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Choose   | Year | Quadmester |
|                                           | 6                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Optional | 1    | 2c         |
| Teaching language                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |          |      |            |
| Department                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |          |      |            |
| Coordinator                               | Collazo Fernández, Antonio                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |          |      |            |
| Lecturers                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |          |      |            |
| E-mail                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |          |      |            |
| Web                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |          |      |            |
| General description                       | A materia aborda a utilización de polímeros reciclados e biocompostos poliméricos en fabricación aditiva, co obxectivo de reducir a dependencia de recursos virxes e promover a xeración de aplicacións máis sostibles. Ademais, explorarase o potencial dos polímeros funcionais para mellorar a eficiencia enerxética e desenvolver solucións innovadoras. Así mesmo, estudaranse as melloras en eficiencia e sustentabilidade na xeración de enerxía a través da fabricación aditiva con metais, achegando coñecementos sobre as súas aplicacións en turbinas, xeradores e sistemas de almacenamento enerxético, entre outros. |          |      |            |

### Resultados de Formación e Aprendizaxe

|      |                                                                                                                                                                                                                       |
|------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Code |                                                                                                                                                                                                                       |
| B1   | Definir os métodos de impresión e os criterios de seguridade e eficiencia para adaptar o deseño dos obxectos á impresión 3D                                                                                           |
| B11  | Recoñecer as posibilidades da fabricación aditiva fronte á fabricación tradicional.                                                                                                                                   |
| C1   | Coñecer e aplicar técnicas de caracterización e análise de materiais (metais, cerámicas, composites, polímeros...) co obxectivo de comprender as súas propiedades e identificar usos potenciais.                      |
| C4   | Seleccionar materiais para aplicacións concretas de manufactura a partir das especificacións das ferramentas e impresoras de manufactura aditiva que empregar, así como dos diferentes tipos de modelados existentes. |
| C7   | Analizar as características dos obxectos que se van a producir para seleccionar o método de impresión máis adecuado.                                                                                                  |
| C9   | Reparar pezas de alto valor engadido e producir pezas de substitución a través do emprego de ferramentas e tecnoloxías de fabricación aditiva                                                                         |

### Resultados previstos na materia

|                                    |                               |
|------------------------------------|-------------------------------|
| Expected results from this subject | Training and Learning Results |
| Coñecementos                       | B1<br>B11                     |
| Habilidades                        | C1<br>C4<br>C7<br>C9          |

### Contidos

|                                                                                                |                                                                                                   |
|------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------|
| Topic                                                                                          |                                                                                                   |
| Tipoloxía de aliaxes metálicas en propulsión e xeración de enerxía                             | Principais aliaxes metálicas en propulsión<br>Principais aliaxes metálicas en xeración de enerxía |
| Aplicación das tecnoloxías L-DED e L-PBF na fabricación e reparación de compoñentes metálicos. | Normativa asociada.<br>Experiencia cun sistema L-DED e aliaxes de alto rendemento.                |
| Polímeros reciclados e biocompostos poliméricos para aplicacións en enerxía máis sostibles.    | Polímeros reciclados<br>Biocompostos                                                              |
| Polímeros funcionais para aplicacións en enerxía.                                              | Principais polímeros funcionais<br>Características                                                |
| Fabricación multimaterial.                                                                     | Necesidade da fabricación multimaterial.<br>Características principais                            |

### Planificación

|  |             |                             |             |
|--|-------------|-----------------------------|-------------|
|  | Class hours | Hours outside the classroom | Total hours |
|--|-------------|-----------------------------|-------------|

|                          |      |      |      |
|--------------------------|------|------|------|
| Lección maxistral        | 16.5 | 28.5 | 45   |
| Prácticas de laboratorio | 22.5 | 22.5 | 45   |
| Traballo tutelado        | 10.5 | 47   | 57.5 |
| Presentación             | 0.3  | 2    | 2.3  |
| Debate                   | 0.2  | 0    | 0.2  |

\*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

| Metodoloxía docente      |                                                                                                                                                                                                                                                                                                                                                                                      |
|--------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                          | Description                                                                                                                                                                                                                                                                                                                                                                          |
| Lección maxistral        | Na sesión maxistral o profesorado, exporá na aula os principais conceptos de cada tema dos que consta a materia. Para isto apoiárase nos medios técnicos dispoñibles: presentacións en powerpoint, videos, etc.                                                                                                                                                                      |
| Prácticas de laboratorio | A maior parte da docencia interactiva realizarase durante ás prácticas de laboratorio. Nelas o alumnado dividido en grupos reducidos, poderán ver a aplicación dos principais conceptos teóricos revisados na aula anteriormente. Estas clases poderán constar de videos interactivos, onde deberán traballar sobre os contidos do mesmo; prácticas de procesado, conferencias, etc. |
| Traballo tutelado        | Traballo tutelado: Coma parte avaliable da materia, o alumnado fará un ou dous traballos. A idea é que o/a estudante correlacione os conceptos vistos na materia de forma práctica nun suposto real, que aprenda a consultar fontes bibliográficas especializadas, que aprenda a traballar en grupo, linguaxe técnica, linguaxe inclusiva, etc.                                      |
| Presentación             | O alumnado fará unha breve exposición oral ao resto da clase.                                                                                                                                                                                                                                                                                                                        |
| Debate                   | O debate iniciárase mediante a apertura por parte do profesor, seguida dunha sesión de preguntas relacionada co tema exposto.                                                                                                                                                                                                                                                        |

| Atención personalizada |                                                              |
|------------------------|--------------------------------------------------------------|
| Methodologies          | Description                                                  |
| Traballo tutelado      | Orientación no desenvolvemento do traballo individual/grupo. |

| Avaliación        |                                                                                                                                                                                                                  |               |                               |                |
|-------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|-------------------------------|----------------|
|                   | Description                                                                                                                                                                                                      | Qualification | Training and Learning Results |                |
| Traballo tutelado | Valorarase a calidade da memoria presentada.                                                                                                                                                                     | 40            | B1<br>B11                     | C1<br>C4<br>C7 |
| Presentación      | Durante a exposición, demostrarán o coñecemento adquirido e a súa capacidade de comunicación ao explicar de maneira clara e concisa os aspectos relevantes do seu traballo.                                      | 30            | B1<br>B11                     | C1<br>C4<br>C7 |
| Debate            | Realizaranse preguntas relacionadas co tema, ás cales deberán responder de forma precisa e fundamentada, demostrando a súa comprensión profunda do tema e a súa capacidade para aplicar os conceptos aprendidos. | 30            | B1<br>B11                     | C1<br>C4<br>C7 |

#### Other comments on the Evaluation

**Primeira edición da Acta. Avaliación continua:** A avaliación continua realizarase durante o período de impartición da materia. A nota final da primeira edición será a suma das notas obtidas no conxunto das probas de avaliación.

**Primeira edición da Acta; Renuncia á avaliación continua:**

Aqueles alumnos que non se acollan á avaliación continua serán avaliados cun exame final sobre os contidos da totalidade da materia, que supoñerá o 100% da nota.

**Exame de Xullo (2ª Edición)** No exame de xullo non se terá en conta a avaliación continua. Poderase obter o 100% da cualificación no exame que se realizará na data previamente fixada polo centro.

| Bibliografía. Fontes de información                                                                                                                                                        |  |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|
| Basic Bibliography                                                                                                                                                                         |  |
| Complementary Bibliography                                                                                                                                                                 |  |
| Peyre, Patrice, and Eric Charkaluk., <b>Additive Manufacturing of Metal Alloys 1: Processes, Raw Materials and Numerical Simulation.</b> , . Newark: John Wiley & Sons, Incorporated, 2022 |  |
| Sarker, Dyuti et al, <b>Metal Additive Manufacturing.</b> , Newark: John Wiley & Sons, Incorporated, 2021                                                                                  |  |
| Brandt, Milan, <b>Laser Additive Manufacturing&amp;#8239;; Materials, Design, Technologies, and Applications</b> , Ed. Milan Brandt. Amsterdam: Elsevier, 2017                             |  |

Froes, Francis, and Rodney Boyer, **Additive Manufacturing for the Aerospace Industry.**, Ed. Francis Froes and Rodney Boyer.: Elsevier, 2019

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Bandyopadhyay, Amit, and Susmita Bose, **Additive Manufacturing**, 2nd ed. Boca Ratón: CRC Press, 2020

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Marlene G. Rosato, Dominick V. Rosato, **Plastics Design Handbook**, 2nd ed. Kluwer Academic Publishers, 2001

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Peter C. Powl, **Engineering with Polymers**, Ed. Chapman and Hall, 1983

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## Recomendacións

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| IDENTIFYING DATA                |                                                            |          |      |            |
|---------------------------------|------------------------------------------------------------|----------|------|------------|
| Advanced design for 3D printing |                                                            |          |      |            |
| Subject                         | Advanced design for 3D printing                            |          |      |            |
| Code                            | V04M196V01204                                              |          |      |            |
| Study programme                 | Máster Universitario en Fabricación Aditiva                |          |      |            |
| Descriptors                     | ECTS Credits                                               | Choose   | Year | Quadmester |
|                                 | 6                                                          | Optional | 1st  | 2nd        |
| Teaching language               | Spanish<br>Galician                                        |          |      |            |
| Department                      |                                                            |          |      |            |
| Coordinator                     | Collazo Fernández, Antonio<br>Pereira Domínguez, Alejandro |          |      |            |
| Lecturers                       |                                                            |          |      |            |
| E-mail                          |                                                            |          |      |            |
| Web                             |                                                            |          |      |            |
| General description             |                                                            |          |      |            |

### 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. |
| B11  | Recognise the possibilities of additive manufacturing versus traditional manufacturing.                                                                    |
| C3   | Identify opportunities for the creation of new designs from the possibilities offered by the new design and printing techniques of additive manufacturing. |

### Expected results from this subject

|                                    |                               |
|------------------------------------|-------------------------------|
| Expected results from this subject | Training and Learning Results |
| Knowledges                         | B6<br>B11                     |
| Skills                             | C3                            |

### Contents

|                                                                        |                                                                                                                                                                                                            |
|------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Topic                                                                  |                                                                                                                                                                                                            |
| Design for additive manufacture                                        | Requirements and specifications of the product<br>Generation of models. It includes analysis of costs, analysis of risks, proofs of prototypes.<br>Design detailed of product                              |
| Topological optimisation and Design of *aligeramiento of product       | Aims of optimisation: it includes to determine load applied, the conditions of outline, the available materials.<br>Generate a mesh and apply conditions of load<br>Algorithms of topological optimisation |
| Design of structures of support and definition of optimum orientations | Analysis of product and study of supports<br>Design of structures of support and patterns<br>Study and Determination of orientations                                                                       |

### Planning

|                         | Class hours | Hours outside the classroom | Total hours |
|-------------------------|-------------|-----------------------------|-------------|
| Introductory activities | 3           | 0                           | 3           |
| Problem solving         | 5           | 25                          | 30          |
| Mentored work           | 10          | 40                          | 50          |
| Project based learning  | 25          | 40                          | 65          |
| Presentation            | 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 | Presentation course and development of the same   |
| Problem solving         | Development of problems of real type and proposed |



|                        |                                             |
|------------------------|---------------------------------------------|
| Mentored work          | Memory of the physical work made            |
| Project based learning | Development of the practical cases proposed |

### Personalized assistance

| Methodologies           | Description |
|-------------------------|-------------|
| Introductory activities |             |
| Problem solving         |             |
| Mentored work           |             |
| Project based learning  |             |
| Tests                   | Description |
| Presentation            |             |

### Assessment

|                        | Description                                        | Qualification | Training and Learning Results |    |
|------------------------|----------------------------------------------------|---------------|-------------------------------|----|
| Mentored work          | (*)Realización memoria de proyecto curso realizado | 40            | B11                           | C3 |
| Project based learning | (*)Desarrollo de proyecto                          | 40            | B6                            |    |
|                        |                                                    |               | B11                           |    |
| Presentation           | (*)Presentación durante 15 minutos de propuesta    | 20            | B6                            | C3 |
|                        |                                                    |               | B11                           |    |

### Other comments on the Evaluation

### Sources of information

#### Basic Bibliography

#### Complementary Bibliography

Damir Godec, Joamin Gonzalez-Gutierrez, Axel Nordin, Eujin Pei, & Julia Ureña Alcázar, **A Guide to Additive Manufacturing**, 10.1007/978-3-031-05863-9, Springer, 2020

### Recommendations

| IDENTIFYING DATA    |                                                                                                                                                                                                                                                          |           |      |            |
|---------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|------|------------|
| Prácticas externas  |                                                                                                                                                                                                                                                          |           |      |            |
| Subject             | Prácticas externas                                                                                                                                                                                                                                       |           |      |            |
| Code                | V04M196V01205                                                                                                                                                                                                                                            |           |      |            |
| Study programme     | Máster Universitario en Fabricación Aditiva                                                                                                                                                                                                              |           |      |            |
| Descriptors         | ECTS Credits                                                                                                                                                                                                                                             | Choose    | Year | Quadmester |
|                     | 6                                                                                                                                                                                                                                                        | Mandatory | 1    | 2c         |
| Teaching language   | Castelán Galego                                                                                                                                                                                                                                          |           |      |            |
| Department          |                                                                                                                                                                                                                                                          |           |      |            |
| Coordinator         | Collazo Fernández, Antonio<br>Pereira Domínguez, Alejandro                                                                                                                                                                                               |           |      |            |
| Lecturers           |                                                                                                                                                                                                                                                          |           |      |            |
| E-mail              |                                                                                                                                                                                                                                                          |           |      |            |
| Web                 |                                                                                                                                                                                                                                                          |           |      |            |
| General description | Mediante a realización de prácticas en empresa o alumno poderá aplicar os coñecementos e as competencias adquiridas durante os seus estudos, o que permitirá complementar e reforzar a súa formación e facilitar a súa incorporación ao mercado laboral. |           |      |            |

### Resultados de Formación e Aprendizaxe

|      |                                                                                                                                                                                                             |
|------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Code |                                                                                                                                                                                                             |
| C5   | Resolver situacións, problemas ou continxencias con iniciativa e autonomía no ámbito da súa competencia, con creatividade, innovación e espírito de mellora no traballo persoal e no dos membros do equipo. |
| C6   | Desenvolver a creatividade e o espírito de innovación para responder os retos que se presentan nos procesos e na organización do traballo e da vida persoal.                                                |

### Resultados previstos na materia

|                                    |                               |
|------------------------------------|-------------------------------|
| Expected results from this subject | Training and Learning Results |
| Habilidades                        | C5<br>C6                      |

### Contidos

|                                       |                                                                                                                  |
|---------------------------------------|------------------------------------------------------------------------------------------------------------------|
| Topic                                 |                                                                                                                  |
| Integración en equipo de empresa      | En función da empresa na que se desenvolvan as prácticas integrarase no equipo de *trabjo proposto pola xerencia |
| Análise de problemática proposta      | Estudo de problemas expostos en empresa                                                                          |
| Propostas de solucións e implantación | Desenvolvemento de solucións a *problematica exposta e plan de implantación                                      |

### Planificación

|                                                      | Class hours | Hours outside the classroom | Total hours |
|------------------------------------------------------|-------------|-----------------------------|-------------|
| Prácticum, Practicas externas e clínicas             | 0           | 115                         | 115         |
| Informe de prácticas, prácticum e prácticas externas | 3           | 30                          | 33          |
| Autoavaliación                                       | 0           | 2                           | 2           |

\*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

### Metodoloxía docente

|                                          |                                    |
|------------------------------------------|------------------------------------|
|                                          | Description                        |
| Prácticum, Practicas externas e clínicas | Prácticas a desenvolver en empresa |

### Atención personalizada

| Methodologies                            | Description                                                                                                                                                                                                                 |
|------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Prácticum, Practicas externas e clínicas | O alumno integrarase nun grupo de traballo nunha empresa onde terá a oportunidade de poñer en práctica os coñecementos e as competencias adquiridas durante os seus estudos, e así complementar e reforzar a súa formación. |
| Tests                                    | Description                                                                                                                                                                                                                 |

| Avaliación                                           |                                                                                                                                                             |               |                               |
|------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|-------------------------------|
|                                                      | Description                                                                                                                                                 | Qualification | Training and Learning Results |
| Prácticum, Practicas externas e clínicas             | Avaliación por parte de informe de empresa, no que se indique, obxectivos conseguidos en canto a integración en equipo, resolución de problemas e autonomía | 40            | C5<br>C6                      |
| Informe de prácticas, prácticum e prácticas externas | Memoria escrita de prácticas realizadas e resultados obtidos                                                                                                | 40            |                               |
| Autoavaliación                                       | *Autoevaluación do alumno                                                                                                                                   | 20            |                               |

#### Other comments on the Evaluation

#### Bibliografía. Fontes de información

##### Basic Bibliography

##### Complementary Bibliography

#### Recomendacións

##### Subjects that continue the syllabus

Traballo Fin de Máster/V04M196V01206

##### Subjects that are recommended to be taken simultaneously

Aplicacións en automoción/V04M196V01201

Aplicacións en Enxeñaría biomédica/V04M196V01202

| IDENTIFYING DATA       |                                                                                                                                                                                                                                                                          |           |      |            |
|------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|------|------------|
| Traballo Fin de Máster |                                                                                                                                                                                                                                                                          |           |      |            |
| Subject                | Traballo Fin de Máster                                                                                                                                                                                                                                                   |           |      |            |
| Code                   | V04M196V01206                                                                                                                                                                                                                                                            |           |      |            |
| Study programme        | Máster Universitario en Fabricación Aditiva                                                                                                                                                                                                                              |           |      |            |
| Descriptors            | ECTS Credits                                                                                                                                                                                                                                                             | Choose    | Year | Quadmester |
|                        | 12                                                                                                                                                                                                                                                                       | Mandatory | 1    | 2c         |
| Teaching language      | Castelán<br>Galego<br>Inglés                                                                                                                                                                                                                                             |           |      |            |
| Department             | Enxeñaría dos materiais, mecánica aplicada e construción                                                                                                                                                                                                                 |           |      |            |
| Coordinator            | Collazo Fernández, Antonio                                                                                                                                                                                                                                               |           |      |            |
| Lecturers              |                                                                                                                                                                                                                                                                          |           |      |            |
| E-mail                 |                                                                                                                                                                                                                                                                          |           |      |            |
| Web                    |                                                                                                                                                                                                                                                                          |           |      |            |
| General description    | O Traballo de Fin de Máster (TFM) é un traballo orixinal e persoal que cada estudante realizará de forma autónoma baixo tutorización docente, e debe permitirlle mostrar de forma integrada a adquisición dos contidos formativos e as competencias asociadas ao título. |           |      |            |

### Resultados de Formación e Aprendizaxe

|      |                                                                                                                                                                                                             |
|------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Code |                                                                                                                                                                                                             |
| C5   | Resolver situacións, problemas ou continxencias con iniciativa e autonomía no ámbito da súa competencia, con creatividade, innovación e espírito de mellora no traballo persoal e no dos membros do equipo. |
| C6   | Desenvolver a creatividade e o espírito de innovación para responder os retos que se presentan nos procesos e na organización do traballo e da vida persoal.                                                |
| D1   | Elaborar documentación técnica e administrativa #de acordo con a lexislación vixente e cos requirimentos do cliente. Cumprir coa lexislación vixente que regula a normativa da fabricación aditiva.         |
| D3   | Defender e asegurar o cumprimento da normativa legal e ambiental, así como dos requirimentos de calidade dos materiais, procesos e produtos                                                                 |
| D5   | Avaliar e comparar os requirimentos das diferentes tecnoloxías de fabricación aditiva existentes no mercado para a súa selección nos procesos de produción.                                                 |

### Resultados previstos na materia

| Expected results from this subject                                                                                                                                                                                        | Training and Learning Results |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|
| Elaboración dunha memoria na que se recollan, entre outros, os seguintes aspectos: antecedentes, problemática ou estado da arte, obxectivos, fases do proxecto, desenvolvemento do proxecto, conclusións e liñas futuras. | C5<br>C6<br>D1<br>D3<br>D5    |
| Deseño de equipos, prototipos, programas de simulación, etc, segundo especificacións.                                                                                                                                     | C5<br>C6<br>D1<br>D3<br>D5    |

### Contidos

|                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|----------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Topic                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| Proxectos clásicos de enxeñaría no ámbito da Fabricación Aditiva                       | Poden versar, por exemplo, sobre o deseño e mesmo a fabricación dun prototipo, a enxeñaría dunha instalación de produción, ou a implantación dun sistema no campo da fabricación aditiva. Polo xeral, neles desenvólvese sempre a parte documental da memoria (cos seus apartados de cálculos, especificacións, estudos de viabilidade, seguridade, etc. que se precisen en cada caso), planos, prego de condicións e orzamento e, nalgúns casos, tamén se contempla os estudos propios da fase de execución material do proxecto. |
| Estudos técnicos, organizativos e económicos sobre a aplicación e beneficios de la FA. | Consistentes na realización de estudos relativos a equipos, sistemas, servizos, etc., relacionados cos campos propios da titulación, que traten un ou máis aspectos relativos ao deseño, planificación, produción, xestión, explotación e calquera outro propio do campo da fabricación aditiva, relacionando cando cumpra alternativas técnicas con avaliacións económicas e discusión e valoración dos resultados.                                                                                                               |

Traballos teórico-experimentais relacionados coa fabricación aditiva De natureza teórica, computacional ou experimental, que constitúan unha contribución á técnica no campo da fabricación aditiva incluíndo, cando cumpra, avaliación económica e discusión e valoración dos resultados.

## Planificación

|                            | Class hours | Hours outside the classroom | Total hours |
|----------------------------|-------------|-----------------------------|-------------|
| Actividades introductorias | 5           | 25                          | 30          |
| Traballo tutelado          | 15          | 230                         | 245         |
| Presentación               | 1           | 24                          | 25          |

\*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

## Metodoloxía docente

|                            | Description                                                                                                              |
|----------------------------|--------------------------------------------------------------------------------------------------------------------------|
| Actividades introductorias | O alumno realizará, de forma autónoma, unha procura bibliográfica, lectura, procesamento e elaboración de documentación. |
| Traballo tutelado          | O estudante, de maneira individual, elabora a memoria do Traballo Fin de Máster,                                         |
| Presentación               | O alumnado debe preparar e defender o traballo realizado diante dun tribunal de avaliación .                             |

## Atención personalizada

### Methodologies Description

|                   |                                                                                                                                     |
|-------------------|-------------------------------------------------------------------------------------------------------------------------------------|
| Traballo tutelado | Cada alumno terá un titor e/ou un co-titor encargados de guiarlle, e que lle marcarán as directrices oportunas para realizar o TFG. |
|-------------------|-------------------------------------------------------------------------------------------------------------------------------------|

## Avaliación

| Description       | Qualification Training and Learning Results                               |
|-------------------|---------------------------------------------------------------------------|
| Traballo tutelado | Valorarase a calidade da memoria do Traballo Fin de Máster presentada. 70 |
| Presentación      | Valorarase a defensa do Traballo Fin de Máster. 30                        |

## Other comments on the Evaluation

## Bibliografía. Fontes de información

### Basic Bibliography

### Complementary Bibliography

## Recomendacións

### Other comments

COMPORTAMIENTO ÉTICO DEL ALUMNO: Se espera que el alumno presente un comportamiento ético adecuado y conforme a la normativa recientemente aprobada (18 de abril de 2023) por la Universidade de Vigo, que se concreta en el TÍTULO VII. DO USO DE MEDIOS ILÍCITOS, del REGULAMENTO SOBRE A AVALIACIÓN, A CALIFICACIÓN E A CALIDADE DA DOCENCIA E DO PROCESO DE APRENDIZAXE DO ESTUDANTADO

Requisitos: Para matricularse no Traballo Fin de Grao é necesario superar ou ben estar matriculado de todas as materias da titulación.

Información importante: No momento da defensa do TFM, o alumno deberá ter todas as materias restantes do título superadas.

A orixinalidade da memoria será obxecto de estudo mediante unha aplicación informática de detección de plaxios.