



## Teaching Guide

| Teaching Guide           |                                                                                                                                                                                                                                                                             |        |                                                    |           |
|--------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|----------------------------------------------------|-----------|
| Identifying Data         |                                                                                                                                                                                                                                                                             |        |                                                    | 2017/18   |
| Subject (*)              | Thermo-mechanical properties of materials. Fundamental Methods                                                                                                                                                                                                              |        | Code                                               | 730495003 |
| Study programme          | Mestrado Universitario en Materiais Complexos: Análise Térmica e Reoloxía (plan 2012)                                                                                                                                                                                       |        |                                                    |           |
| Descriptors              |                                                                                                                                                                                                                                                                             |        |                                                    |           |
| Cycle                    | Period                                                                                                                                                                                                                                                                      | Year   | Type                                               | Credits   |
| Official Master's Degree | 2nd four-month period                                                                                                                                                                                                                                                       | First  | Obligatoria                                        | 4         |
| Language                 | English                                                                                                                                                                                                                                                                     |        |                                                    |           |
| Teaching method          | Face-to-face                                                                                                                                                                                                                                                                |        |                                                    |           |
| Prerequisites            |                                                                                                                                                                                                                                                                             |        |                                                    |           |
| Department               | Enxeñaría Naval e Industrial                                                                                                                                                                                                                                                |        |                                                    |           |
| Coordinador              | López Beceiro, Jorge José                                                                                                                                                                                                                                                   | E-mail | jorge.lopez.beceiro@udc.es                         |           |
| Lecturers                | Artiaga Diaz, Ramon Pedro<br>López Beceiro, Jorge José                                                                                                                                                                                                                      | E-mail | ramon.artiaga@udc.es<br>jorge.lopez.beceiro@udc.es |           |
| Web                      |                                                                                                                                                                                                                                                                             |        |                                                    |           |
| General description      | This course presents the thermal properties of materials (glass transition, relaxation mechanisms, phase transitions, thermal stability) and experimental techniques to study (dielectric analysis, thermomechanical, thermogravimetry, differential scanning calorimetry). |        |                                                    |           |

## Study programme competences / results

| Code | Study programme competences / results                                                                                                                                                                 |
|------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| A1   | Set up and conduct tests using the techniques of thermal analysis and rheology most appropriate in each case, within the scope of complex materials                                                   |
| A2   | Identify and evaluate the different types of complex materials                                                                                                                                        |
| B1   | Knowledge and understanding to provide a basis or opportunity for originality in developing and / or applying ideas, often in a research context                                                      |
| B2   | The students have the skill to apply their knowledge and their ability to solve problems in new or unfamiliar contexts within broader (or multidisciplinary) contexts related to their field of study |
| B4   | That the students can communicate their conclusions and the knowledge and last reasons behind that conclusions to specialized and non specialized audience in a clear and unambiguous way             |
| B8   | Applying a critical, logical and creative way of thinking                                                                                                                                             |
| B13  | Analysis-oriented attitude                                                                                                                                                                            |
| B21  | To assess the importance of research, innovation and technological developments in the socio-economic and cultural progress of society                                                                |
| C2   | Have a good command of spoken and writing expression and understanding of a foreign language.                                                                                                         |
| C6   | Critically assessing the knowledge, technology and information available to solve the problems they face with.                                                                                        |
| C7   | To assume as a professional and citizen the importance of learning throughout life.                                                                                                                   |
| C8   | To assess the importance of research, innovation and technological development in the socio-economic and cultural progress of society.                                                                |
| C9   | Appreciate the importance of research in environmental protection                                                                                                                                     |

## Learning outcomes

| Learning outcomes                                                       | Study programme competences / results |                           |                          |
|-------------------------------------------------------------------------|---------------------------------------|---------------------------|--------------------------|
| To know the different thermal transformations may experience a material | AR2                                   | BR1<br>BR2<br>BR8<br>BR21 | CR2<br>CR7<br>CR8<br>CR9 |



|                                                                                       |            |                                          |                          |
|---------------------------------------------------------------------------------------|------------|------------------------------------------|--------------------------|
| To identify different thermal transformations using different experimental techniques | AR1<br>AR2 | BR1<br>BR2<br>BR4<br>BR8<br>BR13<br>BR21 | CR2<br>CR6<br>CR7<br>CR8 |
| To Set up properly the tests                                                          | AR1        | BR2<br>BR13                              | CR8                      |
| To know the possibilities of separation of overlapped processes                       | AR1        | BR1<br>BR2<br>BR13                       |                          |

| Contents                                                |                                                                                                                                                                                        |
|---------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Topic                                                   | Sub-topic                                                                                                                                                                              |
| The glass transition and other relaxation processes     | Transitions of first and second order.<br>Relaxation processes in polymers.<br>The complexity of the glass transition.                                                                 |
| Melting and softening observed by DSC, DEA and rheology | Amorphous and crystalline polymers.<br>Melting and softening.<br>Differential scanning calorimetry<br>Dielectric analysis<br>Thermomechanical analysis<br>Observed by DSC, DEA and TMA |
| Curing processes                                        | Curing: Chemical Crosslinking<br>Observation of cure by DSC, DEA and DMA.                                                                                                              |
| Thermal stability by TG                                 | Thermogravimetric analysis.<br>Methods for evaluating the thermal stability<br>Applications                                                                                            |

| Planning                                                                                                                        |                                          |                                      |                               |             |
|---------------------------------------------------------------------------------------------------------------------------------|------------------------------------------|--------------------------------------|-------------------------------|-------------|
| Methodologies / tests                                                                                                           | Competencies / Results                   | Teaching hours (in-person & virtual) | Student?s personal work hours | Total hours |
| Guest lecture / keynote speech                                                                                                  | A2 B1 B2 B13 B21 C6<br>C7 C8 C9          | 14.5                                 | 14.5                          | 29          |
| Laboratory practice                                                                                                             | A1 B1 B2 B13 C8                          | 25                                   | 15                            | 40          |
| Supervised projects                                                                                                             | A1 B1 B2 B4 B8 B13<br>B21 C2 C6 C7 C8 C9 | 2.5                                  | 22.5                          | 25          |
| Objective test                                                                                                                  | A1 A2 B2 B4 B13                          | 1                                    | 0                             | 1           |
| Personalized attention                                                                                                          |                                          | 5                                    | 0                             | 5           |
| (*)The information in the planning table is for guidance only and does not take into account the heterogeneity of the students. |                                          |                                      |                               |             |

| Methodologies                  |                                                                                                                                                                                                                                                                             |
|--------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Methodologies                  | Description                                                                                                                                                                                                                                                                 |
| Guest lecture / keynote speech | Presentation given by the professor, on a schematic basis, focusing on the main topics, covering both theoretical and practical issues.                                                                                                                                     |
| Laboratory practice            | Performance of practical activities such as demonstrations, exercises, experiments, etc..                                                                                                                                                                                   |
| Supervised projects            | Activities whose purpose is that the students enlarge the study of the topics presented in the program and consolidate their acquired knowledge and capabilities. These activities should also help the students learn and improve their capabilities in literature survey. |
| Objective test                 | Exam that will help to evaluate the knowledge and competencies acquired by the students.                                                                                                                                                                                    |



## Personalized attention

| Methodologies                                                                                     | Description                                                                                                                                                |
|---------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Supervised projects<br>Guest lecture /<br>keynote speech<br>Laboratory practice<br>Objective test | The personalized attention to students, understood as a support in the teaching-learning process, will take place in the hours of tutoring of the teacher. |

## Assessment

| Methodologies                  | Competencies / Results                | Description                                                                                               | Qualification |
|--------------------------------|---------------------------------------|-----------------------------------------------------------------------------------------------------------|---------------|
| Supervised projects            | A1 B1 B2 B4 B8 B13 B21 C2 C6 C7 C8 C9 | Presentation (oral and written) of the supervised work.                                                   | 60            |
| Guest lecture / keynote speech | A2 B1 B2 B13 B21 C6 C7 C8 C9          | Continuous assessment through monitoring of student work in the classroom, laboratory and / or tutorials. | 10            |
| Laboratory practice            | A1 B1 B2 B13 C8                       | Continuous assessment through monitoring of student work in the classroom, laboratory and / or tutorials. | 10            |
| Objective test                 | A1 A2 B2 B4 B13                       | Examination or objective test.                                                                            | 20            |

## Assessment comments

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## Sources of information

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|----------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Basic</b>         | O sistema de Biblioteca de la UDC permite realizar búsquedas de literatura recomendada por profesor e materia. Esta é unha listaxe ampliada de fontes recomendadas: Mechanical properties of polymers and composites / Lawrence E. Nielsen, Robert F. Landel Nielsen, Lawrence E. Esc Politécnica Superior -- CM P 154 Thermal analysis. Fundamentals and applications to material characterization: proceedings of the international seminar: Thermal analysis and rheology. Ferrol, Spain, 30 Juny-4 July, 2003 / Ramón Artiaga Díaz (ed.), A Coruña: Universidade da Coruña, Servicio de Publicacions, 2005, ISBN 84-9749-100-9 Thermal analysis of polymers / edited by Joseph D. Menczel, R. Bruce Prime; Hoboken, N.J.: John Wiley, [2009], ISBN 978-0-471-76917-0 Thermal characterization of polymeric materials / edited by Edith A. Turi, San Diego : Academic Press, 1997, 2nd. ed. ISBN 0-12-703781-0 (v.1) 0-12-703782-9 (v.2) |
| <b>Complementary</b> |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |

## Recommendations

|                                                                    |
|--------------------------------------------------------------------|
| <b>Subjects that it is recommended to have taken before</b>        |
|                                                                    |
| <b>Subjects that are recommended to be taken simultaneously</b>    |
| Termomechanics of Materials Properties. Advanced Methods/730495004 |
| <b>Subjects that continue the syllabus</b>                         |
|                                                                    |
| <b>Other comments</b>                                              |
|                                                                    |

(\*)The teaching guide is the document in which the URV publishes the information about all its courses. It is a public document and cannot be modified. Only in exceptional cases can it be revised by the competent agent or duly revised so that it is in line with current legislation.