



## Teaching Guide

| Teaching Guide      |                                                                       |        |                           |           |
|---------------------|-----------------------------------------------------------------------|--------|---------------------------|-----------|
| Identifying Data    |                                                                       |        |                           | 2022/23   |
| Subject (*)         | Thermodynamics                                                        |        | Code                      | 730G05015 |
| Study programme     | Grao en Enxeñaría Naval e Oceánica                                    |        |                           |           |
| Descriptors         |                                                                       |        |                           |           |
| Cycle               | Period                                                                | Year   | Type                      | Credits   |
| Graduate            | 1st four-month period                                                 | Second | Obligatory                | 6         |
| Language            | Spanish                                                               |        |                           |           |
| Teaching method     | Hybrid                                                                |        |                           |           |
| Prerequisites       |                                                                       |        |                           |           |
| Department          | Ciencias da Navegación e Enxeñaría MariñaEnxeñaría Naval e Industrial |        |                           |           |
| Coordinador         | Lamas Galdo, Isabel                                                   | E-mail | isabel.lamas.galdo@udc.es |           |
| Lecturers           | Cartelle Barros, Juan José                                            | E-mail | juan.cartelle1@udc.es     |           |
|                     | Lamas Galdo, Isabel                                                   |        | isabel.lamas.galdo@udc.es |           |
| Web                 | www.udc.es                                                            |        |                           |           |
| General description | Heat, work, and energy.                                               |        |                           |           |

## Study programme competences

| Code | Study programme competences                                                                                                                                                                                                                           |
|------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| A14  | Knowledge of the applied thermodynamics and of the transmission of the heat.                                                                                                                                                                          |
| B2   | That the students know how to apply its knowledge to its work or vocation in a professional way and possess the competences that tend to prove itself by the elaboration and defense of arguments and the resolution of problems in its area of study |
| B3   | That the students have the ability to bring together and to interpret relevant data (normally in its area of study) to emit judgments that include a reflection on relevant subjects of social, scientific or ethical kind                            |
| B4   | That the students can transmit information, ideas, problems and solutions to a public as much specialized as not specialized                                                                                                                          |
| B5   | That the students developed those skills of learning necessary to start subsequent studies with a high degree of autonomy                                                                                                                             |
| B6   | Be able to carrying out a critical analysis, evaluation and synthesis of new and complex ideas.                                                                                                                                                       |
| C1   | Using the basic tools of the technologies of the information and the communications (TIC) necessary for the exercise of its profession and for the learning throughout its life.                                                                      |
| C4   | Recognizing critically the knowledge, the technology and the available information to solve the problems that they must face.                                                                                                                         |

## Learning outcomes

| Learning outcomes                                                                            | Study programme competences |                            |          |
|----------------------------------------------------------------------------------------------|-----------------------------|----------------------------|----------|
| Model and calculate systems and processes related to the employment and generation of energy | A14                         | B2<br>B3<br>B4<br>B5<br>B6 | C1<br>C4 |

## Contents

| Topic                                                                                                    | Sub-topic                                                                                                    |
|----------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------|
| The following blocks or chapters develop the contents established in the verification memory, which are: | Introduction<br>Conservation of energy<br>Properties of pure substances<br>2nd law<br>Practical applications |



|                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                               |
|----------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. Introduction to thermodynamics                                          | Thermodynamics and energy<br>Systems and control volumes<br>Properties<br>States<br>Processes<br>Energy and enthalpy<br>Specific heat and thermal capacity<br>Phases<br>Ideal gases<br>Temperature and zeroth law of thermodynamics<br>Density<br>Pressure                                                                                                                                                                    |
| 2. Work, energy and the 1st law of thermodynamics (conservation of energy) | Energy<br>Energy transfer by heat<br>Energy transfer by work<br>The first law of thermodynamics for closed systems, energy balance                                                                                                                                                                                                                                                                                            |
| 3. Properties of pure substances                                           | Introduction<br>Phase-change processes of pure substances<br>Property diagrams<br>Property tables<br>Properties of incompressible substances<br>Properties of ideal gases<br>Reference states                                                                                                                                                                                                                                 |
| 4. Conservation of energy and 1st law of thermodynamics                    | Introduction<br>Conservation of mass in control volumes<br>Conservation of energy in control volumes<br>Examples                                                                                                                                                                                                                                                                                                              |
| 5. Thermodynamic cycles and introduction to the 2nd law of thermodynamics  | Introduction<br>Thermal energy reservoirs<br>Thermodynamic cyclic devices: heat engines, refrigerators and heat pumps<br>Kelvin-Planck and Clausius statements for the second law of thermodynamics<br>Maximum thermal efficiency of thermodynamic cyclic devices                                                                                                                                                             |
| 6. Entropy                                                                 | Clausius inequality<br>Entropy<br>Entropy tables<br>Entropy diagrams<br>T-ds relations<br>Entropy change of thermal energy reservoirs<br>Entropy change of incompressible substances<br>Entropy change of ideal gases<br>Entropy generation<br>Isentropic processes<br>Entropy balance for closed systems and control volumes<br>Entropy of the universe<br>Isentropic efficiency of pumps, compressors, turbines and nozzles |

## Planning

| Methodologies / tests | Competencies | Ordinary class hours | Student?s personal work hours | Total hours |
|-----------------------|--------------|----------------------|-------------------------------|-------------|
|-----------------------|--------------|----------------------|-------------------------------|-------------|



|                                                                                                                                 |                             |    |    |    |
|---------------------------------------------------------------------------------------------------------------------------------|-----------------------------|----|----|----|
| ICT practicals                                                                                                                  | A14 B2 B3 B4 B5 B6<br>C1 C4 | 20 | 20 | 40 |
| Guest lecture / keynote speech                                                                                                  | A14 B2 B3 B4 B5 B6<br>C1 C4 | 30 | 30 | 60 |
| Problem solving                                                                                                                 | A14 B2 B3 B4 B5 B6<br>C1 C4 | 20 | 20 | 40 |
| Mixed objective/subjective test                                                                                                 | A14 B2 B3 B4 B5 B6<br>C1 C4 | 9  | 0  | 9  |
| Personalized attention                                                                                                          |                             | 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                   |                               |
|---------------------------------|-------------------------------|
| Methodologies                   | Description                   |
| ICT practicals                  | Classes using software        |
| Guest lecture / keynote speech  | Classes                       |
| Problem solving                 | Classes about problem solving |
| Mixed objective/subjective test | Exam/s                        |

| Personalized attention          |                                                                                                            |
|---------------------------------|------------------------------------------------------------------------------------------------------------|
| Methodologies                   | Description                                                                                                |
| Mixed objective/subjective test | Attention will be provided by personalized attention, e-mail and Teams.                                    |
| Problem solving                 | Academic dispense is allowed. Students who request it must contact teacher to realize additional homework. |
| ICT practicals                  |                                                                                                            |

| Assessment                      |                             |                                      |               |
|---------------------------------|-----------------------------|--------------------------------------|---------------|
| Methodologies                   | Competencies                | Description                          | Qualification |
| Mixed objective/subjective test | A14 B2 B3 B4 B5 B6<br>C1 C4 | Exam/s.                              | 70            |
| ICT practicals                  | A14 B2 B3 B4 B5 B6<br>C1 C4 | Students may deliver some exercises. | 30            |
| Others                          |                             |                                      |               |

| Assessment comments                                                                                                                                                                                                                                                                                                                                                         |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>Students who request academic dispense must realize other activities proposed by the teacher. The qualification is the same as the practice.</p> <p>The evaluation criteria of the 2nd and extra opportunity are the same as those of the 1st opportunity.</p> <p>In order to pass it is necessary to obtain at least 4 in the final exam and 5 in the global score.</p> |

| Sources of information |
|------------------------|
|------------------------|



|                      |                                                                                                                                                                                                                                                                                                                                                                                         |
|----------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Basic</b>         | <ul style="list-style-type: none"><li>- Y. A. Çengel; M. A. Boles. (). Thermodynamics. McGraw-Hill</li><li>- M. Moran y H. N Shapiro (). Fundamentos de Termodinámica Técnica. John Wiley &amp; Sons</li><li>- J. M<sup>a</sup> Sáiz Jabardo (). Introducción a la Termodinámica.</li><li>- Y. A. Çengel (). Ecuaciones Diferenciales para Ingeniería y Ciencias. McGraw-Hill</li></ul> |
| <b>Complementary</b> |                                                                                                                                                                                                                                                                                                                                                                                         |

## Recommendations

### Subjects that it is recommended to have taken before

CALCULUS/730G01101  
PHYSICS I/730G01102  
DIFFERENTIAL EQUATIONS/730G01110  
MECHANICS/730G01118

### Subjects that are recommended to be taken simultaneously

### Subjects that continue the syllabus

FLUID MECHANICS/730G01119  
Industrial Heat Transfer/730G03020  
Fluid and Thermal Machines/730G03023

### Other comments

proposed to correct them.

5/5