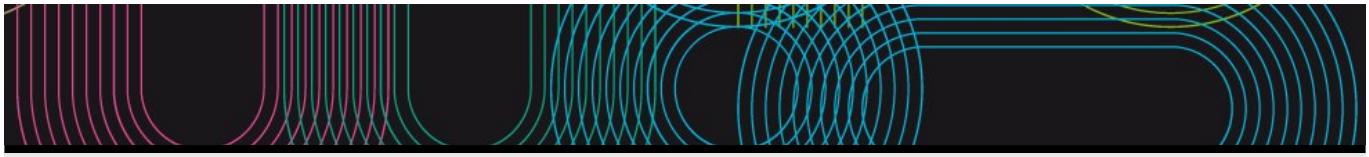

| IDENTIFYING DATA | | | | |
|---|---|---|---|---|
| **Physics: Thermal systems** | | | | |
| Subject | Physics: Thermal systems | | | |
| Code | V09G290V01306 | | | |
| Study programme | Degree in Energy Engineering | | | |
| Descriptors | ECTS Credits | Choose | Year | Quadmester |
| | 6 | Basic education | 2nd | 1st |
| Teaching language | English | | | |
| Department | | | | |
| Coordinator | Granada Álvarez, Enrique<br>Baqueiro Vidal, María | | | |
| Lecturers | Baqueiro Vidal, María<br>Granada Álvarez, Enrique<br>Ogando Martínez, Ana | | | |
| E-mail | egranada@uvigo.es<br>m.baqueirovidal@gmail.com | | | |
| Web | http://faitic.uvigo.es/ | | | |
| General description | The aim of the subject is that the students purchase the necessary knowledges to be able to tackle ingeneering projects where the thermal energy was involved taking into account the interaction between systems and as they affect the interactions the thermal properties of the substances that configure them. It looks for a macroscopic classical approach understanding, perfect and improve the performance of those processes in which there is exchange of energy in general and thermal in particular. | | | |

| Competencies | |
|---|---|
| Code | |
| C4 | Understanding and mastery of basic concepts of the general laws of mechanics, thermodynamics, waves, fields and electromagnetism and how they can be applied to solve engineering problems. |
| D1 | Capacity to interrelate all the acquired knowledge and interpret it as components in a body of knowledge with a clear structure and strong internal coherence |
| D2 | Capacity to develop a complete project in any field included in this type of engineering, suitably combining acquired knowledge, accessing necessary information sources, undertaking the necessary enquiries and integrating into inter-disciplinary work teams. |
| D3 | Propose and develop practical solutions, which develop suitable strategies based on theoretical knowledge, for problem phenomena and situations that arise as everyday realities in engineering |
| D4 | Encourage work based on cooperation, communication skills, organization, planning and recognition of responsibility in a multilingual and multidisciplinary working environment that fosters education in equality, peace and respect for fundamental rights |
| D7 | Capacity to organise, interpret, assimilate, create and manage all the information needed to organise their work, handling the I.T., mathematical, physical and other tools required |
| D8 | Conceive engineering within a framework of sustainable development with an awareness of environmental issues |

| Learning outcomes | | |
|---|---|---|
| Expected results from this subject | Training and Learning | Results |
| To know the technological base that supports most of the recent investigations in applications of the thermodynamic engineering. | C4 | D2<br>D3<br>D7<br>D8 |
| To understand the basic concepts related to mass and energy balance in thermal systems. | C4 | D1<br>D3 |

| | | |
|---|---|---|
| To know the experimental procedure used working with energy transference. | | D1<br>D2<br>D7<br>D8 |
| To master the available technicis for the analysis of thermal systems. | C4 | D3<br>D4 |
| To delve into the techniques use during the analysis of processes. | C4 | D2<br>D4 |

| **Contents** | |
|---|---|
| Topic | |
| INTRODUCTORY CONCEPTS AND DEFINITIONS | Thermodynamic system. Thermodynamic properties. Units. Temperature. |
| THERMAL EQUILIBRIUM AND TEMPERATURE | Thermal balance, principle zero of the thermodynamics. Concept of temperature. |
| THERMAL STATE EQUATIONS AND THERMAL PROPERTIES OF A SYSTEM. | Equation of thermal state. Thermal properties of a system. Ideal gases. Equations of state of the real gases. |
| WORK AND THE FIRST PRINCIPLE OF THE THERMODYNAMICS. ENERGETIC PROPERTIES OF A SYSTEM. | Mechanical concept of the energy. Work. Energy of a system. Transfer of energy by heat. Balance of energy in enclosed systems. Energetic properties of a system. Internal energy and enthalpy. Calorific Capacities |
| TRANSFORMATIONS OF A GASEOUS SYSTEM | Transformations of an ideal gas. Politropic Transformations |
| PROPERTIES OF A PURE SUBSTANCE, SIMPLE, AND COMPRESSIBLE | Thermodynamic state. The relation p-v-T. Calculation of thermodynamic properties. Calculation of variations of internal energy and enthalpy. |
| FIRST PRINCIPLE IN OPEN SYSTEMS. CYCLES. | Conservation of the mass. Conservation of the energy. Analysis of volumes of control in stationary state. Transitory states. |
| SECOND PRINCIPLE OF THE THERMODYNAMICS. | Formulation of the Second Principle. Irreversibilities. Application to thermodynamic cycles. Scale Kelvin of temperatures. Maximum performances. Cycle of Carnot. |
| ENTROPY | Inequality of Clausius. The thermodynamic property entropy. Variation of entropy. Calculation of entropy. Reversible processes. Balances of entropy in enclosed and open systems. |

| **Planning** | | | |
|---|---|---|---|
| | Class hours | Hours outside the classroom | Total hours |
| Lecturing | 22 | 45 | 67 |
| Problem solving | 15 | 52.5 | 67.5 |
| Studies excursion | 3 | 0 | 3 |
| Laboratory practical | 10 | 0 | 10 |
| Essay questions exam | 2.5 | 0 | 2.5 |
| *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 professor of the contents of the matter *objecto of study. Bases in which *sustenta. Relation with other matters. Technological applications |
| Problem solving | Formulation, analysis and resolution of problems for the consolidation and application of the theoretical contents. |
| Studies excursion | The realisation of the formative activity Exit of Studies, will be organised and made by the centre, taking like starting point the proposals made by the *profesorado of the matter on the type of installation/company to visit. |
| Laboratory practical | Experimentation of real processes in the laboratory that complement the contents of the matter. |

| **Personalized assistance** | |
|---|---|
| **Methodologies** | **Description** |
| Lecturing | All these activities will be *tuteladas by the professor; well during the hours *lectivas, well during the official hours of *tutorías, or during the review of the proofs and examinations. For all the modalities of teaching, the sessions of *tutorización will be able to make by telematic means (email, videoconference, forums of *FAITIC, ...) Under the modality of *concertación previous. |
| Problem solving | All these activities will be supervised by the professor; or during the lessons hours, or during the official hours of tutorials, or during the review of the proofs and examinations |
| Laboratory practical | All these activities will be supervised by the professor; or during the lessons hours, or during the official hours of tutorials, or during the review of the proofs and examinations |

**Assessment**

| | Description | Qualification | Training and Learning Results | |
|---|---|---|---|---|
| Lecturing | It values through three type test examinations of the theoretical lessons. The first when subject 6 ends, the second when finalising the subject 7 and the third will be coincident with the final exam and will be about subjects 8 and 9. Each one of these theoretical exams will mark 5% of the final note.<br><br>RESULTS OF LEARNING:<br>Comprise the concept of thermodynamic System and of the thermodynamic properties. Units in which they quantify the thermodynamic properties. Learn to measure temperatures. Comprise the concepts of work, heat and energy of enclosed systems. Transfer of energy of systems. Definition of thermodynamic cycle. Learn to define a thermodynamic state and to calculate the value of the thermodynamic properties strangers from the relations between them. Learn to distinguish an ideal gas and to calculate variations of internal energy and enthalpy. Learn to do balances of energy and mass in volumes of control, so much in stationary state as transient. Understanding of the Second Principle of the thermodynamics. Learn to identify reversible and irreversible processes. Understanding of the consequences of the cycle of Carnot. Comprise the concept of entropy and learn to calculate variations of entropy so much in enclosed systems like open. Isoentropic Performances. Applications of the entropy to calculate transfers of heat and work in reversible processes. | 15 | C4 | D1<br>D2<br>D3<br>D4<br>D7 |
| Laboratory practical | It values through a type test examination when lab practices end.<br><br>RESULTS OF LEARNING:<br>Comprise the concept of thermodynamic System and of the thermodynamic properties. Units in which they quantify the thermodynamic properties. Learn to measure temperatures. Comprise the concepts of work, heat and energy of enclosed systems. Transfer of energy of systems. Definition of thermodynamic cycle. Learn to define a thermodynamic state and to calculate the value of the thermodynamic properties strangers from the relations between them. Learn to distinguish an ideal gas and to calculate variations of internal energy and enthalpy. Learn to do balances of energy and mass in volumes of control, so much in stationary state as transient. Understanding of the Second Principle of the thermodynamics. Learn to identify reversible and irreversible processes. Understanding of the consequences of the cycle of Carnot. Comprise the concept of entropy and learn to calculate variations of entropy so much in enclosed systems like open. Isoentropic Performances. Applications of the entropy to calculate transfers of heat and work in reversible processes. | 5 | C4 | D1<br>D2<br>D3<br>D4<br>D7<br>D8 |
| Essay questions exam | Resolution of problems examination.<br><br>RESULTS OF LEARNING:<br>Comprise the concept of thermodynamic System and of the thermodynamic properties. Units in which they quantify the thermodynamic properties. Learn to measure temperatures. Comprise the concepts of work, heat and energy of enclosed systems. Transfer of energy of systems. Definition of thermodynamic cycle. Learn to define a thermodynamic state and to calculate the value of the thermodynamic properties strangers from the relations between them. Learn to distinguish an ideal gas and to calculate variations of internal energy and enthalpy. Learn to do balances of energy and mass in volumes of control, so much in stationary state as transient. Understanding of the Second Principle of the thermodynamics. Learn to identify reversible and irreversible processes. Understanding of the consequences of the cycle of Carnot. Comprise the concept of entropy and learn to calculate variations of entropy so much in enclosed systems like open. Isoentropic Performances. Applications of the entropy to calculate transfers of heat and work in reversible processes. | 80 | C4 | D1<br>D2<br>D3<br>D4<br>D7<br>D8 |

## Other comments on the Evaluation

The exams of theory and practices prior to the final exam will allow obtaining 1.5 points out of a total of 10 points. The third theory exam, coinciding in time with the final exam, will allow obtaining 0.5 additional points. ALL the exams of theory and practices previous to the final exam will be recoverable in the own final exam in the two existing calls of December and June. The marks obtained in the exams of theory and practices are maintained throughout the academic year.

The final exams will consist of 3 theory exams and 1 of test-type practices, each punctuating 0.5 points. The other 8 points are for problem resolutions.

Exam calendar. Verify / consult in an updated way on the website of the center:

## Sources of information

### Basic Bibliography

Moran, M.J. y Shapiro, H. N., **Fundamentos de termodinámica técnica**, 2ª edición, Reverté, 2004
Çengel, Yunus A., **Termodinámica**, 8ª edición, MacGraw-Hill, 2015
Moran, M.J. y Shapiro, H. N., **Fundamentals of Engineering Thermodynamics**, 5th edition, John Wiley & Sons, 2003
Çengel, Yunus A., **Thermodynamics: An Engineering Approach**, 8th edition, McGraw-Hill, 2015

### Complementary Bibliography

## Recommendations

### Subjects that continue the syllabus

Thermodynamics and heat transfer/V09G290V01302
Generation and distribution of conventional and renewable thermal energy/V09G290V01503
Nuclear engineering/V09G290V01605
Renewable energy installations/V09G290V01604
Thermal engines and turbo-machines/V09G290V01608
Applied heat transmission/V09G290V01606
Thermal energy management/V09G290V01706
Refrigeration and air conditioning technology/V09G290V01702

### Subjects that are recommended to be taken simultaneously

Fluid mechanics/V09G290V01305

## Contingency plan

### Description

Considering the uncertain and unpredictable evolution of the health alert caused by COVID-19, the University establishes an extraordinary planning that will be activated when the administrations and the institution determine it. It is based on safety, health and responsibility, and it guarantees teaching in an online or semi-presential modalities. These already planned measures will guarantee, at the required time, the development of teaching in a more agile and effective way, because they will be known in advance by students and teachers through the standardized tool for teaching guides DOCNET.

1. Semi-presential modality
Once the semi-presential teaching is required, it would mean a reduction of the capacity of the teaching spaces used in the face-to-face modality. Therefore, as the first measure of the centre, the capacity of the teaching spaces would be reformulated and informed to the teachers, in order to proceed to reorganize the formative activities for the rest of the semester. It should be noted that the reorganization will depend on the moment throughout the semester in which this semi-presential modality is activated. For the reorganization of the teaching activities, the following guidelines would be followed:

Through the FaiTIC platform, all the students will be informed about the new conditions under which the formative activities and assessment tests will be carried out at the end of the semester.

The tutorial sessions will be carried out by telematic means (email, videoconference, FAITIC forums, ...) with prior agreement.

Once some of the students have carried out experimental or computer laboratory practices in the face-to-face modality, if it is possible, the rest of the students will have the possibility to perform the same or equivalent activities in the same modality.

For the rest of the activities until the end of the semester, it should be done a proper identification of those formative activities which can be done under face-to-face modality and those which will be carried out remotely.

Regarding the potential tools to be applied for the formative activities during the online mode, CampusRemoto and the FaiTIC platform will be used.

2. Online modality
In the event that the non-face-to-face teaching modality is required (suspension of all face-to-face formative and assessment activities), the tools currently available at the University of Vigo, CampusRemoto and the FaiTIC platform will be used. The reorganization will depend on the moment throughout the semester in which this online modality is activated. In the

reorganization of the teaching activities, the following guidelines would be followed:

2.1. Communication
Through the FaiTIC platform, all the students will be informed about the new conditions under which the formative activities and assessment tests will be carried out at the end of the semester.

2.2. Adaptation and / or modification of teaching methodologies
As the teaching methodologies have been conceived for the face-to-face teaching modality, the teaching methodologies that would be kept and those which would be modified or replaced in the online modality are indicated below.

The teaching methodologies that would be kept, since they can be used in face-to-face and online teaching mode are all except laboratory practices. Instrumental management in aboratory practices will be replaced by videos.

2.3. Adaptation of tutorial sessions and personalized attention
The tutorial sessions may be carried out by telematic means (email, videoconference, FAITIC forums, ...) with prior agreement.

2.4. Evaluation. Type of assessment tests and the weight in the final grade will not be modified.

2.5. Bibliography or additional material to facilitate self-learning would not be modified.