Degree competences to which the subject contributes

Specific:
1. IND_COMMON: Understanding of applied thermodynamics and heat transfer: Basic principles and their application to solving engineering problems.

Transversal:
2. SELF-DIRECTED LEARNING - Level 2: Completing set tasks based on the guidelines set by lecturers. Devoting the time needed to complete each task, including personal contributions and expanding on the recommended information sources.
3. TEAMWORK - Level 2. Contributing to the consolidation of a team by planning targets and working efficiently to favor communication, task assignment and cohesion.
4. EFFECTIVE USE OF INFORMATION RESOURCES - Level 2. Designing and executing a good strategy for advanced searches using specialized information resources, once the various parts of an academic document have been identified and bibliographical references provided. Choosing suitable information based on its relevance and quality.
The aim of the Thermal Systems subject is twofold. Firstly, the aim is to present the basic theoretical concepts in the fields of applied thermodynamics and heat transfer, and their applications in engineering. A second aim is to build up students' creativity and effectiveness in solving problems that require them to apply the concepts they have learnt. In addition, they will be expected to use the thermodynamics software program, TEST (http://energy.sdsu.edu/testcenter/), in order to enable them to solve open-ended problems.

Learning objectives of the subject

The aim of the Thermal Systems subject is twofold. Firstly, the aim is to present the basic theoretical concepts in the fields of applied thermodynamics and heat transfer, and their applications in engineering. A second aim is to build up students' creativity and effectiveness in solving problems that require them to apply the concepts they have learnt. In addition, they will be expected to use the thermodynamics software program, TEST (http://energy.sdsu.edu/testcenter/), in order to enable them to solve open-ended problems.

Study load

<table>
<thead>
<tr>
<th>Total learning time: 150h</th>
<th>Hours large group:</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>45h</td>
<td>30.00%</td>
</tr>
<tr>
<td></td>
<td>15h</td>
<td>10.00%</td>
</tr>
<tr>
<td></td>
<td>0h</td>
<td>0.00%</td>
</tr>
<tr>
<td></td>
<td>0h</td>
<td>0.00%</td>
</tr>
<tr>
<td></td>
<td>90h</td>
<td>60.00%</td>
</tr>
</tbody>
</table>

- Face-to-face lectures and problem solving sessions.
- Face-to-face practical work sessions and exercises.
- Independent learning, preparation of face-to-face sessions and exercises.
- The face-to-face sessions based on problem solving will introduce the theoretical fundamentals of the subject, concepts, methods and results by means of exercises solved step by step.

The practical (problem solving) sessions will basically include:

a) Sessions in which the lecturer will give students guidelines on how to solve problems by applying the knowledge they have acquired in the theoretical sessions (44%).
b) Session in which students will complete work from the subject syllabus (e.g. TEST, the Expert System for Thermodynamics, http://energy.sdsu.edu/testcenter/) (44%).
c) Examination sessions (12%).

Students will be expected to do independent study to:

a) Prepare face-to-face sessions (by reading handouts before attending class).
b) Study the theoretical and practical content of the subject so that they learn concepts by solving the set exercises that will then be handed in and marked.
## Content

<table>
<thead>
<tr>
<th>TOPIC 1: INTRODUCTION TO TECHNICAL THERMODYNAMICS</th>
<th>Learning time: 19h</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Theory classes: 4h 30m</td>
</tr>
<tr>
<td></td>
<td>Practical classes: 1h 30m</td>
</tr>
<tr>
<td></td>
<td>Self study: 13h</td>
</tr>
</tbody>
</table>

**Description:**
- 1.1. Thermodynamic systems
- 1.2. Thermodynamic properties, states, processes and cycles
- 1.3. Operating principles and the classification of heat engines
- 1.4. Historical background to heat engines
- 1.5. Energy, environment and climate change
- 1.6. Energy efficiency, consumption and renewable energies

**Related activities:**
- Test
- Applied exercises

**Specific objectives:**
- For students to:
  - Recognise the concepts of thermodynamic principles, processes and cycles.
  - Differentiate and classify the operating principles of heat engines.
  - Recognise the impact of the use of heat engines on the environment.
# TOPIC 2: PURE SUBSTANCES

## Description:
2.1. T-v, p-v and p-T diagrams
2.2. The p-v-T surface
2.3. Determination of thermodynamic properties
2.4. Simple models of pure substances

## Related activities:
- Test
- Applied exercises

## Specific objectives:
For students to:
- Recognise pure substances and their thermodynamic characterisation.
- Develop the ability to determine the properties of pure substances based on the magnitudes that define their state.
- Recognise and apply the models that make it possible to determine these properties in liquids and solids.
- Understand the concepts of enthalpy and entropy.

## Learning time: 21h
- Theory classes: 6h
- Practical classes: 2h
- Self study: 13h
### TOPIC 3: THE FIRST PRINCIPLE

**Learning time:** 23h  
**Theory classes:** 7h 30m  
**Practical classes:** 2h 30m  
**Self study:** 13h

<table>
<thead>
<tr>
<th>Description:</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1. Closed systems and thermal energy</td>
</tr>
<tr>
<td>3.2. Specific heat, enthalpy and internal energy in ideal gases, solids and liquids.</td>
</tr>
<tr>
<td>3.3. Open systems and enthalpy</td>
</tr>
<tr>
<td>3.4. The principles of the conservation of mass and energy</td>
</tr>
<tr>
<td>3.5. Steady flow devices</td>
</tr>
</tbody>
</table>

**Related activities:**  
Test  
Applied exercises

**Specific objectives:**  
For students to:  
- Recognise the equivalence between the first principle of thermodynamics and the principle of the conservation of energy.  
- Develop the ability to prove the relationship between heat and work depending on the system under study.  
- Apply the simplifications of the first principle to steady flow devices.
### TOPIC 4: THE SECOND PRINCIPLE AND ENTROPY

<table>
<thead>
<tr>
<th>Learning time: 21h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theory classes: 6h</td>
</tr>
<tr>
<td>Practical classes: 2h</td>
</tr>
<tr>
<td>Self study: 13h</td>
</tr>
</tbody>
</table>

#### Description:
4.1. Heat machines, the Carnot cycle and formulations of the second principle
4.2. Clausius inequality and entropy
4.3. Entropy balance in open and closed systems
4.4. Property diagrams that include entropy Isentropic efficiency
4.5. Processes of entropy change in pure substances, solids, liquids and ideal gases

#### Related activities:
- Test
- Applied exercises
- Assessment tests

#### Specific objectives:
For students to:
- Recognise the second principle of thermodynamics as a result of the irreversibility of thermodynamic processes that occur in heat engines.
- Recognise entropy as a corollary of the second principle of thermodynamics.
- Develop the ability to derive entropy balance and work with diagrams that include it as a property.
- Demonstrate the isentropic efficiency of steady flow devices.
### TOPIC 5: ENGINE CYCLES

<table>
<thead>
<tr>
<th><strong>Description:</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>5.1. Steam power cycles</td>
</tr>
<tr>
<td>5.2. Gas power cycles. Turbines, alternative internal and external combustion engines</td>
</tr>
<tr>
<td>5.3. Introduction to combustion processes and their environmental impact</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Related activities:</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Test</td>
</tr>
<tr>
<td>Applied exercises</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Specific objectives:</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>For students to:</td>
</tr>
<tr>
<td>- Define engine cycles as a set of thermodynamic processes that can be studied with the help of the principles of thermodynamics.</td>
</tr>
<tr>
<td>- Develop the peculiarities of engine cycles with steam and gas turbines, and of alternative internal and external combustion engines</td>
</tr>
<tr>
<td>- Recognise and assess the huge environmental impact that the massive use of these cycles have on current society.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Learning time:</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>23h</td>
</tr>
<tr>
<td>Theory classes: 7h 30m</td>
</tr>
<tr>
<td>Practical classes: 2h 30m</td>
</tr>
<tr>
<td>Self study: 13h</td>
</tr>
</tbody>
</table>
# TOPIC 6: GENERATION CYCLES

<table>
<thead>
<tr>
<th>Learning time: 21h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theory classes: 6h</td>
</tr>
<tr>
<td>Practical classes: 2h</td>
</tr>
<tr>
<td>Self study: 13h</td>
</tr>
</tbody>
</table>

**Description:**
6.1. The Rankine and Brayton generation cycles
6.2. Introduction to cooling substances
6.3. Absorption and adsorption cycles

**Related activities:**
- Test
- Applied exercises

**Specific objectives:**
For students to:
- Define generation cycles as a set of thermodynamic processes that can be studied with the help of the principles of thermodynamics.
- Develop the particularities of generation cycles using vapour, turbine and gas compression, and absorption and adsorption.
- Recognise and assess the environmental impact that the use of cooling substances has on current society.
TOPIC 7: HEAT TRANSMISSION

Description:
7.1 Relationship between heat transfer and thermodynamics
7.2. Heat and temperature
7.3. Forms of heat transfer and its physical mechanisms
7.4. Heat transfer by conduction
7.5. Heat transfer by convection
7.6. Heat transfer by radiation
7.7. Combined heat transfer

Related activities:
Test
Applied exercises
Assessment tests

Specific objectives:
For students to:
- Recognise the difference between the approaches to thermodynamic and heat transfer, as well as their complementarity.
- Recognise the physical mechanisms of heat transfer in any phenomenon whatsoever.
- Identify the physical properties associated with heat transfer phenomena.
- Apply fundamental heat transfer equations in simple cases of one-dimensional flow.

Planning of activities

(ENG) CONTROL DE COMPRENSIÓ

(ENG) EXERCICIS D'APLICACIÓ

(ENG) PROVES D'AVALUACIÓ
Qualification system

- 1st exam: 35%
- 2nd exam: 40%
- Questionaries / deliverables: 25%
- The unsatisfactory results of the part of problems of the 1st examination can be redirected through the 2nd examination. Students with a score of less than 3.5 points from the part of problems of the 1st exam will be able to access this redirection which will consist of a double score of a series of questions of the part of problems of the 2nd examination (clearly identified) that will allow to obtain 3.5 points if they are answered correctly. The grade obtained by the application of this redirection will replace the initial grade of the part of problems of the 1st examination as long as it is higher.

For those students who meet the requirements and submit to the reevaluation examination, the grade of the reevaluation exam will replace the grades of all the on-site written evaluation acts (tests, midterm and final exams) and the grades obtained during the course for lab practices, works, projects and presentations will be kept.

If the final grade after reevaluation is lower than 5.0, it will replace the initial one only if it is higher. If the final grade after reevaluation is greater or equal to 5.0, the final grade of the subject will be pass 5.0.

Regulations for carrying out activities

- The evaluation exams (1st and 2nd exams) containing theory questions with multiple choice and / or development of short and problems. For each exam, the weights of the theory and problems will be 30% and 70% respectively.
- The theoretical part of the assessment will be made without any recourse other than paper and pen. The problems of the assessment can be made, moreover, in a form provided by the subject teachers and available to Athena.
- The tests will be conducted in a maximum time of 165 minutes.

Bibliography

Basic:


Complementary:
