

## Course guide

### 230462 - TERMO - Thermodynamics

Last modified: 25/05/2023

<b>Unit in charge:</b>	Barcelona School of Telecommunications Engineering		
<b>Teaching unit:</b>	748 - FIS - Department of Physics.		
<b>Degree:</b>	BACHELOR'S DEGREE IN ENGINEERING PHYSICS (Syllabus 2011). (Compulsory subject).		
<b>Academic year:</b> 2023	<b>ECTS Credits:</b> 6.0	<b>Languages:</b> Catalan	

#### LECTURER

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<b>Coordinating lecturer:</b>	Consultar aquí / See here: <a href="https://telecos.upc.edu/ca/estudis/curs-actual/professorat-responsables-coordinadors/responsables-assignatura">https://telecos.upc.edu/ca/estudis/curs-actual/professorat-responsables-coordinadors/responsables-assignatura</a>
<b>Others:</b>	Consultar aquí / See here: <a href="https://telecos.upc.edu/ca/estudis/curs-actual/professorat-responsables-coordinadors/professorat-assignat-idioma">https://telecos.upc.edu/ca/estudis/curs-actual/professorat-responsables-coordinadors/professorat-assignat-idioma</a>

#### DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

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##### Specific:

1. Ability to solve problems in thermodynamics, heat transfer and fluid mechanics, in the fields of physics, aerodynamics, geophysics and engineering.

##### Generical:

3. ABILITY TO IDENTIFY, FORMULATE, AND SOLVE PHYSICAL ENGINEERING PROBLEMS. Planning and solving physical engineering problems with initiative, making decisions and with creativity. Developing methods of analysis and problem solving in a systematic and creative way.

##### Transversal:

2. TEAMWORK - Level 2. Contributing to the consolidation of a team by planning targets and working efficiently to favor communication, task assignment and cohesion.

1. 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.

#### TEACHING METHODOLOGY

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There will be three theoretical and two practical weekly sessions. The theoretical lectures will be devoted to a careful presentation of the basic concepts and the main results which will be illustrated with some examples. The practical sessions will be devoted to the solution of a variety of exercises and problems.

#### LEARNING OBJECTIVES OF THE SUBJECT

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- \* Comprehension of basical principles in which thermodynamics is based
- \* Applications of these concepts to the solving of practical problems
- \* Comprehensión of the link with other fields in physics and engineering



## STUDY LOAD

Type	Hours	Percentage
Hours large group	65,0	43.33
Self study	85,0	56.67

Total learning time: 150 h

## CONTENTS

### 1. Basic concepts

**Description:**

Introduction thermodynamics. Thermodynamic system, variable thermodynamic equilibrium state, transformation thermodynamics. Zero principle and Temperature. Thermometers and empirical thermometric scales.

**Full-or-part-time:** 9h 11m

Theory classes: 2h 30m

Practical classes: 1h 36m

Self study : 5h 05m

### 2. Monocomponent simple systems

**Description:**

Simple Systems: Definition and Properties. PVT simple systems: thermal equation of state and thermal coefficients. Ideal Gas. Real gases and PVT surface . Vapor-liquid, solid-liquid and solid vapor equilibria. Triple point and critical point. Polymorphism. Thermal equation of state of real gas. Law of corresponding states. Compressibility factor.

**Full-or-part-time:** 19h 12m

Theory classes: 5h 50m

Practical classes: 3h 12m

Self study : 10h 10m

### 3. Calorimetry and heat propagation

**Description:**

Heat capacity. Specific heat. Heat transmission. Thermal conductivity. Fourier law. Thermal conductivity: one-dimensional and stationary. Dimensional transient conduction. Convection of heat. Thermal black body radiation. Stefan-Boltzmann law and Wien's law.

**Full-or-part-time:** 17h 13m

Theory classes: 4h 10m

Practical classes: 1h 36m

Self study : 11h 27m

#### 4. First law of thermodynamics

**Description:**

Expansion work on simple systems PVT. Dissipative work. Conjugate variables and configuration work on other simple systems: work surface, working torque, electric and magnetic polarization work. First Principle of Thermodynamics. Internal energy. Enthalpy.

**Full-or-part-time:** 14h 22m

Theory classes: 4h 20m

Practical classes: 2h 24m

Self study : 7h 38m

#### 5. First law of thermodynamics: energetic properties and applications

**Description:**

Gay Lussac-Joule experiment. Energetic properties of ideal gas: Joule's law. Joule-Kelvin experiment. Energetic properties of real gas: Generalized Joule's law. Energetic properties of a simple PVT system. Transformations of an ideal gas thermodynamic.

**Full-or-part-time:** 13h 38m

Theory classes: 3h 36m

Practical classes: 2h 24m

Self study : 7h 38m

#### 6. Second law of thermodynamics: Heat engines

**Description:**

Heat engines, fridges and thermobombs. Carnot cycle. Second Law of Thermodynamics: Statements of Clausius and Kelvin-Planck. Carnot's theorem. Examples of engines: Otto Cycle, Diesel Cycle.

**Full-or-part-time:** 14h 22m

Theory classes: 4h 20m

Practical classes: 2h 24m

Self study : 7h 38m

#### 7. Second law of thermodynamics: Entropy

**Description:**

Clausius theorem. Entropy. Entropy of an ideal gas. Entropy of a mixture of ideal gases. Entropic statement of Second Law of Thermodynamics. Heat and TS diagram. Principle of Carathéodory. Degradation of energy. Absolute scale of temperature. Entropy and disorder.

**Full-or-part-time:** 11h 21m

Theory classes: 3h

Practical classes: 2h

Self study : 6h 21m

## 8. First and second law in open systems

### Description:

Volume control. Principle of conservation of mass in a volume control. Principle of conservation of energy in a volume control. Energy equations in a volume control. Engineering applications in stationary regime. Balance of entropy in a volume control. Analysis entropic processes in stationary regime.

**Full-or-part-time:** 18h 10m

Theory classes: 4h 48m

Practical classes: 3h 12m

Self study : 10h 10m

## 9. Thermodynamic potentials

### Description:

Thermodynamic potential in simple systems pvt. Maxwell relations. Equilibrium conditions. Equations TdS. Mayer relationships in simple PVT systems. Generalization of the Maxwell relations to other simple systems. Mayer generalized equation. Joule-Kelvin coefficient. General conditions of equilibrium. Fluctuations. Le Chatelier's principle.

**Full-or-part-time:** 14h 21m

Theory classes: 4h 19m

Practical classes: 2h 24m

Self study : 7h 38m

## 10. Phase transition in monocomponent systems

### Description:

Condition of phase equilibrium in simple PvTsystems. First-order phase transitions: Clausius-Clapeyron equation. Stable and metastable domains. Undercooled liquids and glass transition. Higher-order phase transitions: theories of Ehrenfest and Landau. Superconducting transition. Critical phenomena. Lambda transition in  $^4\text{He}$ . Liquid and solid helium. Ferromagnetic transition.

**Full-or-part-time:** 13h 38m

Theory classes: 3h 36m

Practical classes: 2h 24m

Self study : 7h 38m

## 11. Absolut zero and third law of thermodynamics

### Description:

Inaccessibility of absolute zero. Postulates of Nernst and Planck statement of the third law of thermodynamics. Thermodynamic properties near absolute zero. Summary of the principles of thermodynamics from an axiomatic point of view.

**Full-or-part-time:** 4h 32m

Theory classes: 1h 12m

Practical classes: 0h 48m

Self study : 2h 32m

## GRADING SYSTEM

There will be a final exam (EF) and a partial exam (EP). The students' participation in practical sessions will be also taken into account (P). The final score will follow from  $\max\{EF, 0.65*EF + 0.30*EP + 0.05*P\}$



## BIBLIOGRAPHY

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### Basic:

- Ortega Girón, Manuel R.; Ibañez Mengual, José A. Lecciones de física: termología. 5a ed. Murcia: Diego Marin, 2003. ISBN 8484253341.
- Aguilar Peris, José. Curso de termodinámica. 3 ed. Madrid: Alhambra, 1989. ISBN 8420513822.
- Barrio Casado, María del [et al.]. Problemas resueltos de termodinámica. Madrid: Thomson, 2005. ISBN 8497323491.
- Barrio, M. del [et al.]. Termodinámica básica: ejercicios [on line]. 2006. Barcelona: Edicions UPC, 2006 [Consultation: 10/03/2015]. Available on: <http://hdl.handle.net/2099.3/36828>. ISBN 9788483018712.

### Complementary:

- Sears, F.W.; Salinger, G.L. Termodinámica, teoría cinética y termodinámica estadística. 2a ed. Barcelona: Reverté, 2002. ISBN 978-8429141610.
- Zemansky, Marc Waldo; Dittman, Richard H. Calor y termodinámica. 6a ed. Madrid: McGraw-Hill, 2009. ISBN 8485240855.
- Çengel, Yunus A.; Boles, Michael A. Termodinámica [on line]. 7a ed. México: McGraw-Hill Interamericana, 2009 [Consultation: 27/11/2020]. Available on: <https://ebookcentral.proquest.com/lib/upcatalunya-ebooks/detail.action?docID=3214360>. ISBN 9786071507433.