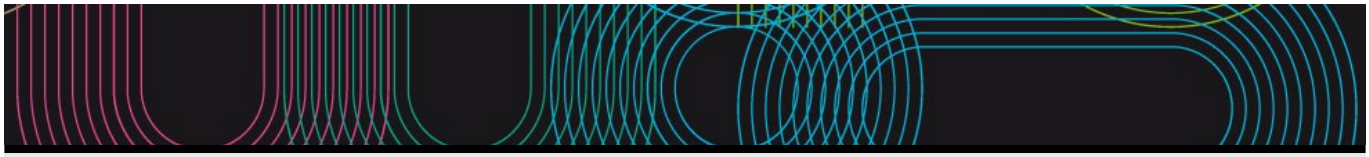

IDENTIFYING DATA				
Thermodynamics				
Subject	Thermodynamics			
Code	O07G410V01303			
Study programme	(*)Grao en Enxeñaría Aeroespacial			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Mandatory	2nd	1st
Teaching language	Spanish			
Department				
Coordinator	Cerdeiriña Álvarez, Claudio			
Lecturers	Cerdeiriña Álvarez, Claudio Troncoso Casares, Jacobo Antonio			
E-mail	calvarez@uvigo.es			
Web	http://aero.uvigo.es			
General description	Students will be instructed on the concepts, Laws, and main applications of the basic science of Thermodynamics.			

Competencies	
Code	
B2	Planning, documentation, project management, calculation and manufacturing in the field of aeronautical engineering (in accordance with what is established in section 5 of order CIN / 308/2009), aerospace vehicles, propulsion systems, aerospace materials, airport infrastructures, air navigation infrastructures and space management, air traffic and transport management systems.
C8	Understand thermodynamic cycles generating mechanical power and thrust.
C16	Appropriate knowledge applied to engineering: Concepts and laws that govern the processes of transfer of energy, the movement of fluids, the mechanisms of transmission of heat and the interchange of matter and its role in the analysis of the main propulsion systems in aerospace engineering.
C19	Applied knowledge of: science and technology of materials; mechanics and thermodynamics; fluid mechanics; aerodynamics and flight mechanics; navigation and air traffic systems; aerospace technology; theory of structures; airborne transportation; economy and production; projects; environmental impact.
D1	Capability of analysis, organization and planification.
D3	Capability of oral and written communication in native lenguage
D4	Capability of autonomous learning and information management
D5	Capability to solve problems and draw decisions
D6	Capabiliity for interpersonal communication
D8	Capabiliity for critical and self-critical reasoning

Learning outcomes			
Expected results from this subject	Training and Learning Results		
Knowledge, comprehension, application, analysis and synthesis of the principles and methods of Thermodynamics.	B2	C8 C16 C19	D1 D3 D4 D5 D6 D8
Knowledge and comprehension of the first and second laws of Thermodynamics and their applications to open systems, with illustration for some typical examples in Aerospace Engineering.	B2	C8 C16 C19	D1 D3 D4 D5 D6 D8

Knowledge, comprehension and application of the generalized thermodynamic relations, the equilibrium and stability contitions of simple compressible systems and phase transitions.	B2	C8 C16 C19	D1 D3 D4 D5 D6 D8

Contents

Topic	
First law.	Energy and temperature. Thermodynamic processes and reversibility. Pressure-volume work. Adiabatic work and heat. Equation of state and volumetric coefficients. Heat capacity. Thermodynamic relations in pVT systems from isochoric, isobaric, isothermal and adiabatic processes. Appendix 1.1. Heat transfer.
Second law.	Interconversion of heat and work. Carnot cycle and absolute temperature. Entropy. Irreversibility, law of entropy increase and extremal principle.
Thermodynamic potentials and formal structure.	Thermodynamic potentials, extensivity and concavity. Euler equation and Gibbs-Duhem equation. Legendre transforms. Extremal principle for F and G. Extremal principle for U, concavity, convexity and second derivatives. Maxwell relations and Gibbs-Helmholtz equations. Appendix 3.1. Real gases. Appendix 3.2. Elasticity. Appendix 3.3. Surface thermodynamics.
Phase transitions.	Phase rule. Phase diagrams. Clapeyron equations. Liquid-gas transition in the van der Waals model. Second-order transitions. Third law.
Thermofluidics.	Control volumes. Conservation of mass. Work flux and energy in a fluid in motion. Analysis of energy of systems of stationary flux. Engineering devices of stationary flux.
Laboratory	Itinerary "Equation of State": Ideal gas; Adiabatic coefficient; Joule-Thomson effect. Itinerary "Phase transitions": Liquid-vapor equilibrium; Critical point; Ferromagnetism. Itinerary "Miscellaneous": Specific heat of solids; Engines; Stefan-Boltzmann law.

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	19	43.5	62.5
Seminars	20	44	64
Laboratory practical	11	10	21
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	The most relevant parts of the course shall be taught in one-hour sessions. Active participation of students will be welcome.
Seminars	Every hour will be devoted to supplement Master Sessions as well as to the resolution of exercises. Active participation of students will be welcome.
Laboratory practical	Once assessment of parts devoted to theory and exercises is finished, students will enter the laboratory under the teacher's supervision. Student's autonomy will be encouraged.

Personalized assistance

Methodologies	Description
Laboratory practical	Performance of each student will be supervised.

Assessment

	Description	Qualification	Training and Learning Results		
Lecturing	Jointly with that relative to Seminars, an exam will be held during classes, which will carry exemption for those students getting a qualification greater than 7 points (over 10).	20	B2	C8 C16 C19	D1 D3 D4 D5 D6 D8

Seminars	Jointly with that relative to Master Sessions, an exam will be held during classes, which will carry exemption for those students getting a qualification greater than 7 points (over 10).	20	B2	C8 C16 C19	D1 D3 D4 D5 D6 D8
Laboratory practical	Assessment will be made in January, in the laboratory and via an exam.	10	B2	C8 C16 C19	D1 D3 D4 D5 D6 D8
Essay questions exam	An exam for the whole course contents will be held on the official date.	50	B2	C8 C16 C19	D1 D3 D4 D5 D6 D8

Other comments on the Evaluation

To go further in December/January, a qualification greater than 5 (over 10) will be required. This corresponds to the joint assessment of the official exam and the exam during classes. Secondly, a qualification greater than 5 (over 10) will also be required for the laboratory part. These thresholds being overcome, the final qualification will be obtained according to the balance indicated above.

To go further in June/July, a qualification greater than 5 (over 10) in an exam over the whole course contents (theory, exercises and laboratory) will be required. That exam will be held on the official date.
The June/July criterion applies to any student that do not take classes regularly.
The dates of the final exams are published on the website of the EEAE in the web page http://aero.uvigo.es/gl/docencia/exames.

Sources of information

Basic Bibliography

J. F. Tester, M. Modell, **Thermodynamics and Its Applications**, 3ª ed., Prentice Hall, 1996
M. Alonso, E. J. Finn, **Física**, Addison-Wesley Iberoamericana, 1992
H. B. Callen, **Termodinámica**, 1ª ed., Editorial AC, 1981
H. B. Callen, **Thermodynamics and an Introduction to Thermostatistics**, 2ª ed., John Wiley & Sons, 1985
L. I. Sedov, **Mechanics of Continuous Media**, World Scientific, 1997
Y. A. Cengel, M. A. Boles, **Termodinámica**, 8ª edición, McGraw-Hill, 2015

Complementary Bibliography

D. Kondepudi, I. Prigogine, **Modern Thermodynamics**, John Wiley & Sons, 1998
B. Widom, **Thermodynamics - Equilibrium**, Encyclopedia of Applied Physics, Vol. 21, Wiley, 1997

Recommendations

Subjects that continue the syllabus

Fluid mechanics/O07G410V01402

Subjects that it is recommended to have taken before

Physics: Physics I/O07G410V01103