COURSE DATA

Data Subject	
Code	34245
Name	Thermodynamics
Cycle	Grade
ECTS Credits	7.5
Academic year	2021 - 2022

Study (s)

Degree	Center	Acad. year	Period
1105 - Degree in Physics	Faculty of Physics	2	First term
1928 - Double Degree Program Physics-Mathematics	Double Degree Program Physics and Mathematics	2	First term
1929 - Double Degree Program in Physics and Chemistry	Double Degree Program Physics and Chemistry	2	First term

Subject-matter

Degree	Subject-matter	Character
1105 - Degree in Physics	7 - Thermodynamics and statistical physics	Obligatory
1928 - Double Degree Program Physics-Mathematics	2 - Segundo Curso (Obligatorio)	Obligatory
1929 - Double Degree Program in Physics and Chemistry	2 - Segundo Curso (Obligatorio)	Obligatory

Coordination

Name	Department
GARCIA MORALES, VLADIMIR	345 - Earth Physics and Thermodynamics
MANZANARES ANDREU, JOSE ANTONIO	345 - Earth Physics and Thermodynamics

SUMMARY

Thermodynamics is a compulsory subject of 7.5 ECTS. Given that the concepts and methods of thermodynamics are applicable to macroscopic systems of any nature, the subject is closely related to many other subjects of the degree, although its complementarity with the Laboratory of Thermodynamics and Statistical Physics stands out. It is also basic for the development of the subject Physics of the Atmosphere.

PREVIOUS KNOWLEDGE

Relationship to other subjects of the same degree

There are no specified enrollment restrictions with other subjects of the curriculum.

Other requirements

Differential calculus of several variables. Integral calculus of one variable. Units and orders magnitude of quantity of matter, density, energy, temperature, ... Energy concept. Basic concepts of elasticity of one-dimensional systems. Basic concpets of electrical and magnetic polarization of materials.

COMPETENCES (RD 1393/2007) // LEARNING OUTCOMES (RD 822/2021)

1105 - Degree in Physics

- Knowledge and understanding of the fundamentals of physics in theoretical and experimental aspects, and the mathematical background needed for its formulation.
- To know how to apply the knowledge acquired to professional activity, to know how to solve problems and develop and defend arguments, relying on this knowledge.
- Problem solving: be able to evaluate clearly the orders of magnitude in situations which are physically different, but show analogies, thus allowing the use of known solutions in new problems .
- Theoretical understanding of physical phenomena: have a good understanding of the most important physical theories (logical and mathematical structure, experimental support, described physical phenomena).
- Be able to understand and master the use of the most commonly used mathematical and numerical methods.
- Modelling & Problem solving skills: be able to identify the essentials of a process / situation and to set up a working model of the same; be able to perform the required approximations so as to reduce a problem to an approachable one. Critical thinking to construct physical models.
- Basic & applied Research: acquire an understanding of the nature and ways of physics research and of how physics research is applicable to many fields other than physics, e.g. engineering; be able to design experimental and/or theoretical procedures for: (i) solving current problems in academic or industrial research; (ii) improving the existing results.

- Foreign Language skills: Have improved command of English (or other foreign languages of interest) through: use of the basic literature, written and oral communication (scientific and technical English), participation in courses, study abroad via exchange programmes, and recognition of credits at foreign universities or research centres.
- Learning ability: be able to enter new fields through independent study, in physics and science and technology in general.
- Communication Skills (written and oral): Being able to communicate information, ideas, problems and solutions through argumentation and reasoning which are characteristic of the scientific activity, using basic concepts and tools of physics.
- Students must have acquired knowledge and understanding in a specific field of study, on the basis of general secondary education and at a level that includes mainly knowledge drawn from advanced textbooks, but also some cutting-edge knowledge in their field of study.
- Students must be able to apply their knowledge to their work or vocation in a professional manner and have acquired the competences required for the preparation and defence of arguments and for problem solving in their field of study.
- Students must have the ability to gather and interpret relevant data (usually in their field of study) to make judgements that take relevant social, scientific or ethical issues into consideration.
- Students must be able to communicate information, ideas, problems and solutions to both expert and lay audiences.
- Students must have developed the learning skills needed to undertake further study with a high degree of autonomy.

LEARNING OUTCOMES (RD 1393/2007) // NO CONTENT (RD 822/2021)

Understanding of the influence of thermal motion on the dynamics of macroscopic systems. Comprehension of concepts such as internal energy, entropy, temperature, thermodynamic potentials, fundamental thermodynamic relation, reversibility, etc. Methods of Thermodynamics: derivation of thermodynamic relations, use of different representations (entropic, Gibbs, Helmholtz, ...), thermodynamic diagrams, etc.. Application to diverse physical systems. Experimental measurement techniques for thermodynamic quantities.

DESCRIPTION OF CONTENTS

1. Introduction to thermodynamics

Thermodynamic systems and their interactions. General principle. State quantities. Zeroth law. Internal energy. Indepependent variables and state functions. Thermodynamic phenomena.

2. The principles of thermodynamics

Thermodynamic processes. Work. First law. Heat. Heat capacity. Entropy of a perfect gas. Second law. Entropy production in some irreversible processes. Third law.

3. Gibbs, Euler and Gibbs-Duhem equations

Gibbs equations. Equilibrium conditions. Euler and Gibbs-Duhem equations. Differential calculus in thermodynamics. Thermal and energetic coefficients. Maxwell relations. Thermodynamic stability conditions.

4. Thermodynamic potentials

tatements of the second law for different constraints. Thermodynamic representations. Gibbs-Helmholtz equations. Maximum work theorem. Exergy

5. Statistical thermodynamics applied to some systems

Boltzmann entropy equation. Lattice gas. Thermal radiation. Crystalline solid. Heat capacity of diatomic and polyatomic gases. Ideal quantum gases.

6. Gases and gas mixtures

Real gas equations of state. Fugacity. Joule-Thomson throttling. Gas mixtures.

7. Phase transitions

Phase diagrams p-v-T. Discontinuous phase transition. Biphasic systems. Clausius-Clapeyron equation. Continuous phase transitions. Magnetic phase transitions.

8. Thermodynamics of elastic filaments

Thermodynamic description of elastic filaments. Ideal elastic systems. Rubber elasticity. Shape memory alloys

9. Mixtures and solutions

Binary mixtures. Activity. Mixing and excess quantities. Colligative properties of solutions. Isothermal liquid-vapour equilibria. Isobaric phase equilibria. Gibbs phase rule. Partial molar quantities.

10. Interfacial thermodynamics

Interfacial excess quantities. Young-Laplace equation. Monocomponent interfacial systems. Kelvin equation. Gibbs-Thomson-Freundlich equation. Homogenous nucleation. Binary interfacial systems. Gibbs adsorption equation. Nanothermodynamics.

11. Chemical equilibria

Chemical equilibria in gas phase. Chemical equilibria in solution. Electrochemical processes.

12. Thermodynamics of irreversible processes

Thermodynamics of continuous media. State quantities for non-equilibrium systems. Phenomenological equations. Heat conduction. Thermoelectric phenomena. Balance equations and conservation equations.

WORKLOAD

ACTIVITY	Hours	% To be attended
Theory classes	60,00	100
Tutorials	15,00	100
Development of individual work	3,00	0
Preparation of evaluation activities	45,00	0
Preparing lectures	28,50	0
Preparation of practical classes and problem	36,00	0
TOTAL	187,50	

TEACHING METHODOLOGY

In the lectures the syllabus is developed using both the blackboard and the video projector. The material is presented following a logical, rigorous and well-structured approach that the students should master to describe accurately the behaviour of macroscopic systems.

Students will have copies of the ppt slides used in classroom by the lecturer, and should prepare the lectures to optimize learning. Further reading is strongly recommended. Questions designed to promote teacher-student interaction will be addressed when convenient. They serve to identify and clarify the more difficult concepts.

Practical sessions are intended primarily to get the students actively involved in problem solving. They must solve, individually or in groups, the problems with the help of the lecturer. In addition to the problems worked out in class, books containing solved exercises are also recommended.

In the tutorial sessions, the students may get answers for question on theoretical concepts as well as on the resolution of exercises.

EVALUATION

Learning is assessed through a written exam (mark EE, between 0 and 10) and continuous assessment (mark EC, between 0 and 10) through exercises proposed in the lectures.
If EE >= 3.5 and EC >= 3.5, the final grade (between 0 and 10) is F = EE + 0.2EC [1 - (EE/10)^3].
If 3.5 > EE or 3.5 > EC, then F = EE. The requirement to pass the course is F >= 5.

The written exam consists of a theoretical module (60 % weight) and a problem-solving module (40 %). The first one consists of four questions that can be practical (resolution of a short exercise), conceptual or numerical (requiring knowledge of conversions of units and typical orders of magnitude) that must be resolved without notes or books, only calculator. The problem-solving module contains two problems, and use of a personal collection of formulas (stapled, maximum of 5 double-sided pages or 10 pages on one side) is allowed.

REFERENCES

Basic

- Carrington, G. Basic Thermodynamics, Oxford U. P., Oxford, 1996.
- Fernández Pineda, C.; Velasco, S. Termodinámica, Ed. Univ. Ramón Areces, Madrid, 2009.

Additional

- Velasco, S.; Fernández Pineda, C. Problemas de Termodinámica, Ed. Univ. Ramón Areces, Madrid, 2010.
- Pellicer, J.; Manzanares, J. A. 100 Problemas de Termodinámica, Alianza Editorial, Madrid, 1996.
- Pellicer, J.; Mafé, S. Cuestiones de Termodinámica, Alhambra Universidad, Madrid, 1989.
- Pellicer, J.; Tejerina, F. Problemas de Termodinámica con soluciones programadas, Universidad de Valladolid, Valladolid, 1997.
- Ansermet, J.P.; Brechet, S. D. Principles of Thermodynamics, Cambridge U. P., Cambridge, 2019. (Incluye excelente colección de problemas resueltos.)
- Pelton, A.D. Phase Diagrams and Thermodynamic Modeling of Solutions, Elsevier Science, Amsterdam, 2018
- Dill, K. A.; Bromberg, S. Molecular driving forces: statistical thermodynamics in biology, chemistry, physics, and nanoscience, 2ª ed. Garland Science, New York, 2011.
- Bokstein, B. S.; Mendelev, M. I.; Srolovitz, D. J. Thermodynamics and kinetics in materials science a short course, Oxford U. P., New York, 2005.

- Aguilella, V.; Pellicer, J. Termodinámica Aplicada, Univ. Jaume I, Castellón, 1998.
- Zamora, M. Termo, Vols. 1 y 2 (problemas), Secr. Publ. Univ. Sevilla, Sevilla, 1998.
- Pitzer, K. S. Thermodynamics, McGraw-Hill, New York, 1995.
- Callen, H.B. Thermodynamics and an Introduction to Thermostatistics, Wiley, New York, 1985

ADDENDUM COVID-19

This addendum will only be activated if the health situation requires so and with the prior agreement of the Governing Council

In case that health situation requires blended teaching, the teaching model approved by the Academic Degree Committee on July 23, 2020 will be adopted.
For lectures this model consist of 50% student attendance in the classroom, while the rest of students attend the class in streaming broadcast. Two groups will be set with alternate days attendance to the classroom in order to guarantee 50% of teaching hours attendance for all students.
The rest of the teaching activities (laboratories, computer rooms, tutorials) will have a 100% attendance.
If a total reduction in attendance is necessary, classes will be broadcast by synchronous videoconference at their regular schedule, along the period determined by the Health Authority.