# COURSE DATA

| Data Subject | |
|---|---|
| **Code** | 34251 |
| **Name** | Thermodynamics laboratory |
| **Cycle** | Grade |
| **ECTS Credits** | 5.0 |
| **Academic year** | 2020 - 2021 |

**Study (s)**

| Degree | Center | Acad. year | Period |
|---|---|---|---|
| 1105 - Degree in Physics | Faculty of Physics | 2 | First term |

**Subject-matter**

| Degree | Subject-matter | Character |
|---|---|---|
| 1105 - Degree in Physics | 10 - Experimental physics laboratory | Obligatory |

**Coordination**

| Name | Department |
|---|---|
| GARCIA MORALES, VLADIMIR | 345 - Earth Physics and Thermodynamics |
| ONRUBIA FUERTES, JUAN ELECTO | 345 - Earth Physics and Thermodynamics |

# SUMMARY

The *Thermodynamics Laboratory* (5 ECTS), a part of the Subject-Matter *Experimental Physics Laboratory* (25 ECTS), is a core course of the Degree in Physics which is taught in the first quarter of the second year. The subject is conceptually related to *Thermodynamics*, which is also a second year subject, and illustrates experimentally the thermodynamics phenomena described in this theoretical course. Its seriously recommended not to attend *Laboratory of Thermodynamics* without attending either simultaneously or subsequently to the *Thermodynamics* course.

# PREVIOUS KNOWLEDGE

### Relationship to other subjects of the same degree

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

### Other requirements

Students should be familiar with the contents of the course Iniciación a la Física Experimental, which is offered in the second quarter of the first year.

## OUTCOMES

### 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.
- Ability to collect and interpret relevant data in order to make judgements.
- Capacity to communicate information, ideas, problems and solutions to a specialist and a general audience.
- Developing learning skills so as to undertake further studies with a high degree of autonomy.
- 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 .
- Have become familiar with most important experimental methods and be able to perform experiments independently, estimate uncertainties, as well as to describe, analyse and critically evaluate experimental data according to the physical models involved. Know how to use basic instrumentation.
- 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.
- Resolución de problemas y destrezas informáticas: Ser capaz de interpretar cálculos de forma independiente, incluso cuando sea necesario un pequeño PC o un gran ordenador, incluyendo el desarrollo de programas de software. En el contexto de esta materia, dominio de, al menos, un programa de análisis de datos de carácter científico.
- Investigación básica y aplicada: Adquirir una comprensión de la naturaleza de la investigación Física, de las formas en que se lleva a cabo, y de cómo la investigación en Física es aplicable a muchos campos diferentes, por ejemplo la ingeniería; habilidad para diseñar procedimientos experimentales.
- Destrezas generales y específicas en lenguas extranjeras: Mejorar el dominio del inglés y, específicamente, del inglés científico-técnico a través del acceso a la bibliografía básica o a la presentación de trabajos en este idioma.

- Búsqueda de bibliografía: Ser capaz de buscar y utilizar bibliografía en Física y otra bibliografía técnica, así como cualquier fuente de información relevante para trabajos experimentales.
- Ser capaz de proseguir con el estudio de otras materias de la física gracias al bagaje adquirido en el contexto de esta materia.
- Cultura General en Física: Haberse familiarizado con las áreas más importantes de la mecánica en relación con la Física en general, y con enfoques que abarcan y relacionan diferentes áreas de la Física.

## LEARNING OUTCOMES

• To be familiar with the processes, techniques and measurement tools of *Thermodynamics*.
• To apply the scientific method in the experimental work.
• To carry out measurements in the laboratory following an established protocol.
• To estimate the systematic and random errors and identify strategies to minimize them.
• To be familiar with least squares data fitting and estimate the model parameters from the same.
• To develop physical intuition, make estimations to identify the key system properties, and recognize spurious results (even if they are within the allowed error bars).
• To interpret properly the experimental results and draw conclusions from them.
• To complete scientific reports (paying attention not only to scientific language but also to the presentation of tables and figures).
• To apply computer techniques and software for the acquisition, processing and analysis of experimental data.

## DESCRIPTION OF CONTENTS

### 1. Laboratory demonstrations

1. Gas thermometer.
2. Calibration of a thermocouple.
3. Expansion coefficient.
4. Adiabatic coefficients of gases.
5. Adiabatic processes in gases.
6. Thermoelectricity: Peltier module.
7. Heat flux in metal bars.
8. Thermal radiation.
9. Cryoscopy.
10. Liquid-vapor equilibrium of water.
11. Eutectic point.
12. Liquid-vapor equilibrium in binary mixtures.
13. Miscibility diagram of phenol + water.
14. Solid-vapor equilibrium of ammonium carbamate.
15. Thermodynamics of reversible batteries.
16. Heat engines.
17. Microscopic interpretation of S and T.

18. Curie temperature of the Monel alloy.

## WORKLOAD

| ACTIVITY | Hours | % To be attended |
|---|---|---|
| Laboratory practices | 50,00 | 100 |
| Development of group work | 15,00 | 0 |
| Development of individual work | 15,00 | 0 |
| Study and independent work | 15,00 | 0 |
| Readings supplementary material | 10,00 | 0 |
| Preparation of evaluation activities | 20,00 | 0 |
| **TOTAL** | **125,00** | |

## TEACHING METHODOLOGY

Most lab sessions are practical. The lab experiments are selected by the professor and incorporated to the student weekly schedule. All experiments include a guide explaining the procedures. The student must read this guide before doing the experiment.

The lab sessions are conducted with 16 students (distributed in 8 pairs) per professor.

Each pair of students will have a lab book to be supervised by the professor. This book contains all pertinent information for each session: experimental schemes and material, data acquisition procedure, and results (including tables, graphs, estimation of errors, etc.). The student should collect on the notebook the relevant information and personal understanding of the lab demonstrations. The student should note that this book will be useful for studying the materials subject to subsequent evaluation.

Students are expected to fully complete the demonstration during the laboratory session. Upon request, students should deliver the notebook to the professor before leaving for continuous monitoring of the lab work. The notebook will be inspected and returned at the beginning of the next session.

At the request of the professor, students will write a report of some lab demonstrations to be evaluated. Also, the student may be asked to give an oral presentation on a public, interactive session with the other students. Both technical and communication skills can be assessed and evaluated.

The professor who is in charge of the group will explain to the students the particular characteristics required for the written reports and oral exhibitions, if any.

Finally, the professor may insert a preliminary theoretical lecture introducing the Thermodynamics lab. The contents of this lecture usually include the operation rules of this laboratory as well as brief reviews of basic concepts concerning the scientific language, data acquisition, and experimental errors.

## EVALUATION

Attendance at the laboratory is mandatory. Five possible contributions to assess and evaluate:

• Lab Notebook
• Reports
• Written examination

• Practical examination
• Oral presentation.

All the above options may include individual and/or collective (small groups of two students) evaluations, as established by the professor.

The professor will inform about the relative weight of each contribution. The professor may establish a minimum score for any of the above contributions.

## REFERENCES

### Basic

- MANZANARES, J.A., GILABERT, M.A., MAFÉ, S., FERRER, C., MARTÍNEZ, D., BALLESTER, F., SAAVEDRA, G. GONZÁLEZ, P., CROS, A. (coord.) (2010). Guía de laboratorio para el primer ciclo del Grado en Física, Universitat de València.
- Guiones de Prácticas del Laboratorio de Termodinámica (disponibles en el aula virtual).
- THOMPSON, A.; TAYLOR, B. N., Guide for the Use of the International System of Units (SI), NIST Special Publication 811, 2008.

### Additional

- LIDE, D.R. (2001). Handbook of Chemistry and Physics. 82nd ed. CRC Press, Inc. London.
- RAZNJEVIC, K. (1995): Handbook of Thermodynamic Tables. Begell House, New York.
- SÁNCHEZ DEL RIO, C (1989): Análisis de errores. Eudema, Madrid 1989.
- TAYLOR, J R. (1997) An Introduction to Error Analysis. 2nd ed., University Science Books, Sausalito, California.

## ADDENDUM COVID-19

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

## English version is not available