ANEXO I

Escuela Técnica Superior de Ingeniería

GENERAL SPECIFICATIONS

BACHELOR IN ELECTRICAL ENGINEERING

Subject Data

Name:	
Engineering Thermodynamics	
English name:	
Engineering Thermodynamics	
Code:	**Type:**
606310203, 609417203	Compulsory

Hours:			
	Total	**In class**	**Out class**
Time distribution	150	60	90

ECTS:				
Standard group	**Small groups**			
	Classroom	**Lab**	**Practices**	**Computer classroom**
4.5	0.75	0.75		

Departments:	**Knowledge areas:**
Ingeniería Eléctrica y Térmica, de Diseño y Proyectos	Máquinas y Motores Térmicos
Year:	**Semester**
2º	1º

TEACHING STAFF

Name:	**E-mail:**	**Telephone**
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Others Data (Tutoring, schedule...)

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SPECIFIC INFORMATION OF THE COURSE

1. Contents description:

1.1 In English:

Introduction to thermodynamics.
Laws of thermodynamics.
Thermodynamic properties of pure substances.
Energy and mass balances in open systems.
Heat engines.
Steam cycles.
Gas cycles.
Refrigeration cycles.

1.2 In Spanish:

Introducción a la Termodinámica.
Principios de la Termodinámica.
Propiedades de las Sustancias Puras.
Balances de Materia y Energía en sistemas abiertos.
Máquinas Térmicas.
Ciclos de potencia de vapor.
Ciclos de potencia de gas.
Ciclos de refrigeración.

2. Background:

2.1 Situation within the Degree:

Thermodynamics develops basic concepts needed for the training of an electrical engineer.

In that sense, the subject is essential for the graduates with a solid theoretical base and experimental, whose analytical, design and laboratory experiences make them attractive to the industry.

The knowledge acquired is useful in the study of subjects such as power plants, automotive, heat and cold, environmental engineering, alternative sources of energy, etc.

2.2 Recommendations

It is recommended having passed Phisics and Maths.

3. Objectives (as result of teaching):

Understanding of the first law of thermodynamics and energy balance in Open and closed system.

Second principle of thermodynamics analysis and its application to the calculation of performances and efficiencies.

Understanding the basic processes of power and cooling cycles.

Analysis of the air conditioning processes.

4. Skills to be acquired

4.1 Specific Skills:

C01: Knowledge of applied thermodynamics and heat transmission. Basic principles and their application to solving engineering problems

C10: Basic knowledge and application of environmental technologies and sustainability

4.2 General, Basic or Transversal Skills:

CB5. Develop the learning skills required to undertake further studies with a high degree of autonomy.
G01: Problem-solving ability
G04: Ability to apply knowledge in practice
G07: Capacity for analysis and synthesis
G09: Creativity and inventive spirit in solving scientific and technical problems
G12: Capacity for autonomous and deep learning
G14: Ability to manage information in the solution of problematic situations
G16: Sensitivity for environmental issues
G17: Capacity for critical reasoning
CT2: Development of a critical attitude in relation to the capacity of analysis and synthesis.
CT3: Development of an attitude of inquiry that allows the revision and permanent advancement of knowledge.

5. Training Activities and Teaching Methods

5.1 Training Activities:

- Theory sessions on the contents of the Program.
- Problem-Solving Sessions.
- Practical sessions in specialized laboratories or computer rooms.
- Activities Academically Directed by the Faculty: seminars, conferences, development of works, debates, collective tutorials, evaluation activities and self-evaluation.

5.2 Teaching Methods::

- Participatory Master Class.
- Development of Practices in Specialized Laboratories or Computer Classrooms in small groups.
- Problem Solving and Practical Exercises.
- Individual or Collective Tutorials Direct interaction between teachers and students.
- Approach, Realization, Tutoring and Presentation of Works.
- Evaluations and Exams

5.3 Development and Justification:

In theory sessions the basic concepts of each subject will be developed. These sessions will last 45 minutes more or less. The rest of the class will be solving problems, dedicating the rest (duration approximately 45 minutes). Depending on the subject, the one and a half hour slot assigned to this subject may be devote entirely to develop a theory topic or to make a session of problems. Laboratory practices will last 5 sessions. Each session involves a work in the laboratory of approximately 1.5 hours, work It will be held in small groups (4-5 students per group). A report on the laboratory work done. In addition, 7.5 hours are included to to deep in the problem analysis.

6. Detailed Contents

ANEXO I

1. INTRODUCTION.
1.1. Introduction.
1.2. System, Properties, State and Equilibrium.
1.3. Thermodynamic Processes.
1.4. Fundamental Properties.
1.5. Zeroth Law of Thermodynamics: Temperature.

2. FIRST LAW OF THERMODYNAMICS.
2.1. Introduction.
2.2. Energy Transfer by Work.
2.3. The First Law of Thermodynamics: Internal Energy.
2.4. Energy Transfer by Heat.
2.5. Energy Balance for Closed Systems.
2.6. Energy Analysis of Steady-Flow Systems.

3. PROPERTIES OF PURE SUBSTANCES.
3.1. State Postulate.
3.2. Phase-Change Processes
3.3. Thermodynamic Diagrams for Phase-Change Processes
3.4. Property Tables.
3.5. Specific Heat.
3.6. Incompressible Substance Model.
3.7. Ideal Gas Model.

4. SECOND LAW OF THERMODYNAMICS.
4.1. Introduction.
4.2. Thermal Energy Reservoirs. Heat Engines, Refrigerators and Heat Pumps.
4.3. Statements for the Second Law.
4.4. Reversible and Irreversible Processes.
4.5. Second Law Corollaries. Absolute Temperature Scale.

5. ENTROPY.
5.1. Clausius Inequality.
5.2. Entropy.
5.3. The Increase of Entropy Principle.
5.4. Entropy Balance.
5.5. Determination of the Entropy Change.
5.6. Thermodynamic Diagrams Including Entropy.
5.7. Isentropic Processes. Isentropic Efficiciency.
5.8. Reversible Steady-Flow Processes.

6. STEAM POWER CYCLES.
6.1. Introduction
6.2. The Carnot Vapor Cycle.
6.3. Rankine Cycle.
6.4. Efficiency increase of a Rankine Cycle.
6.5. Internal Reheat.
6.6. Regeneration.
6.7. Cogeneration.

7. GAS POWER CYCLES.
7.1. Introduction.
7.2. Air-Standard Assumptions.
7.3. The Otto Cycle.
7.4. The Diesel Cycle.
7.5. The Dual Cycle.
7.6. Gas Turbine Cycle: The Brayton Cycle.
7.7. The Brayton Cycle with regeneration.
7.8. Ideal Jet-Propulsion Cycles.
7.9. Modifications to Turbojet Engines.

8. REFRIGERATION AND HEAT PUMP SYSTEMS.
8.1. Introduction.
8.2. The Reversed Carnot Cycle.

8.3. Vapor-Compression Refrigeration.
8.4. Refrigerant Properties.
8.5. Heat Pumps.
8.6. Gas Refrigeration Cycles.

9. IDEAL GAS MIXTURES AND PSYCHROMETRIC APPLICATIONS.
9.1. Non-Reactive Mixtures of Ideal Gases.
9.2. Thermodynamic Properties of Humid Air.
9.3. Adiabatic Saturation. Wet-Bulb Temperatures.
9.4. Psychrometric Chart.
9.5. Air-Conditioning Processes.

7. Bibliography

7.1 Basic Bibliography:

- Thermodynamics. K. Wark and D.E. Richards (McGraw-Hill, 6th ed., 2000).

- Fundamentals of Engineering Thermodynamics, M.J. Moran and H.N. Shapiro (John Wiley and sons, 6th ed., 2008).

- Engineering Thermodynamics, J.B. Jones and R.E. Dugan (Prentice Hall, 1997).

- Thermodynamics. . An Engineering Approach. Y.A. Çengel and M.A. Boles (McGraw-Hill, 6th ed., 2008).

7.2 Additional Bibliography:

8. Systems and Assessment Criteria

8.1 System for Assessment:

- Theory and problems Exam
- Lab defense report
- Individual Student Monitoring

8.2 Assessment Criteria and Marks:

8.2.1 Examinations Convocatory I

Traditional assessment (CONTINUOUS ASSESSMENT)

In order to assess student learning and their level of acquisition of skills, this subject will follow a semi-continuous evaluation system that will develop during the school period. This system will be the default evaluation unless the student specifically expresses its desire to benefit from the Single Final Evaluation system.. The student's overall grade will be established based on the result obtained in each of the evaluation tests (mandatory and/or voluntary) that will be carried out throughout the semester. The tests to be carried out will be the following:

- Attendance at laboratory practices, carrying out tests, and elaboration of a memory of experimental results (MANDATORY). The practices will take place in the ETSI Thermal Engines and Machines laboratory. There will be 5 90min meetings Attendance will be compulsory. The five sessions will take place during the school term and are not recoverable. The exact days of these five sessions will be pre-established in the schedules degree officials when the School publishes them. It is the student's responsibility to ensure that you will be able to attend them.
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- In the student's attitude during the laboratory sessions, and in the content of the reports, the acquisition of the G04, G07, G14, G16, G17, CT2 skills will be evaluated. It will be a requirement to pass the subject that the practice mark is equal to or greater than 3 out of 10.
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- The Lab practices are not recoverable. If they have been carried out normally and have been valued with a mark higher than 3, referred mark will be kept in the rest of the calls (in the second, in the third and in the extraordinary). If you have not attended them, or if the mark obtained has not exceeded the minimum of 3, the subject will be failed.

- Voluntary work with individual monitoring of the student. Depending on the needs or particularities of the group of students, the teacher will propose a development work on a specific topic or analytical work to resolve issues. Voluntary work must be carried out during the school term. Its realization will allow evaluating the acquisition of competencies C01, C10, G01, G04, G07, G09, G12, G14, G17, CB5, TC2 and TC3. The work will be scored with a grade from 0 to 10 taking into account, not only the its content, but also the student's learning level during its completion.

  The work will require a minimum grade of 6 out of 10 to be taken into account in the qualification global, and its weight in it will be 10%. The voluntary work note will only be valid in the first call. Exceptionally, and at the discretion of the teacher, it may also be kept for the second. But in no case will the voluntary work grade be valid in calls later: neither in the third nor in the extraordinary.

- A comprehensive written examination of theory and problems (MANDATORY). In this exam, all the contents taught in the subject will be asked. It will consist of a series of theoretical questions and problems where the skills CB5, G01, G04, G07, G09, G12, G17, CT3 will be evaluated. The global exam will be scored with a grade from 0 to 10, and will have a weight 85% in the overall grade of the subject (75% if the student does voluntary work).It will be a requirement to pass the course that the overall exam grade is equal to or greater than 5 out of 10.

QUALIFICATION

The global qualification of the subject will be calculated by weighting the note of the different tests in the following way:

- Overall grade = 0.15 × Lab practices grade + 0.85 × Overall exam score

If the course work is voluntary, the overall grade will be calculated as:

- Overall grade = 0.15 × Lab practices grade + 0.75 × Overall exam score + 0.10 x Voluntary work grade

In any case, it will be a requirement to pass the subject that the average global grade of all the tests is equal to or greater than 5, and that all the minimum grade requirements mentioned above have been met: >3 in the practices and >5in the overall exam.

Students who, for justified reasons, cannot attend the Lab practice sessions, they must communicate to the coordinator of the course in the first two weeks of the course and present the corresponding proof to benefit from the Final Evaluation system Unique. Students who carry out any type of activity (work, lab tice or exam) from the beginning of the course without having expressly stated their intention to take advantage of the Single Final Evaluation will be considered by default to take Continuous Evaluation and in no way may they be considered in the record as "Not presented".

8.2.2 Examinations Convocatory II

To assess student learning and their level of acquisition of skills in the second call , there will be a single evaluation test consisting of a global written exam of theory, problems .The grade for this exam will count 85% in the overall grade for the subject. The practice grade will weigh the remaining 15%.

Theory and problems exam. The exam will ask about all the contents taught in the subject. It will be a requirement to pass the subject that the grade is equal to or greater than 5 and that the average overall grade of the exam and practices is also higher than 5.

Lab practices. The lab practices grade is kept by default from the first call to the second. If the student carried out the Lab work normally during the period academic year, and your work was graded with a grade higher than 3, that grade will be retained also in the second call. If the student did not attend, or if the grade did not exceed the minimum
of 3, the subject will be failed.

QUALIFICATION
The overall grade for the subject will be calculated by weighting the grade of the different tests. As the following way:

Global grade = 0.15 × Lab practice grade + 0.85 × Exam grade

8.2.3 Examinations Convocatory III

To assess student learning and their level of acquisition of skills in the third call , there will be a single evaluation test consisting of a global written exam of theory, problems .The grade for this exam will count 85% in the overall grade for the subject. The Lab practice grade will weigh the remaining 15%.

Theory and problems exam. The exam will ask about all the contents taught in the subject. It will be a requirement to pass the subject that the grade is equal to or greater than 5 and that the average overall grade of the exam and practices is also higher than 5.

Lab practices. The lab practices grade is kept by default from the first call to the second. If the student carried out the Lab work normally during the period academic year, and your work was graded with a grade higher than 3, that grade will be retained also in the second call. If the student did not attend, or if the grade did not exceed the minimum
of 3, the subject will be failed.

QUALIFICATION
The overall grade for the subject will be calculated by weighting the grade of the different tests. As the following way:

Global grade = 0.15 × Lab practice grade + 0.85 × Exam grade

8.2.4 Extraordinary Convocatory

To assess student learning and their level of acquisition of skills in the third call , there will be a single evaluation test consisting of a global written exam of theory, problems .The grade for this exam will count 85% in the overall grade for the subject. The Lab practice grade will weigh the remaining 15%.

Theory and problems exam. The exam will ask about all the contents taught in the subject. It will be a requirement to pass the subject that the grade is equal to or greater than 5 and that the average overall grade of the exam and practices is also higher than 5.
Lab practices. It will be two cases: (i) The student has been enrolled in the subject for the 2023-2024 academic year;
(ii) that has not been and that has passed the practices in other previous courses.

i. If the student carried out the Lab practice properly during the school period of the
academic year 2023-2024, and your work was graded with a grade higher than 3, this grade will be retained. If the student did not attend, or if the grade did not passthe minimum of 3, the subject will be failed.

ii. If the student was not enrolled in the subject in the 2023-2024 academic year, but has a Lab practice grade higher tha 3 from a previous course, then he can request the recognition by writing to the coordinator of the subject within the same period that administratively requests participation in the call. If the validation is positive the old Lab practice grade will be used to calculate the overall grade of the subject with its corresponding weight (15%). If , despite having a Lab practice grade in the previous course, validation is not granted (due to differences in the number or type of Lab practice), then the student will be evaluated in a written test on same day of the official extraordinary call exam that will weigh 15% in the overall rating.

QUALIFICATION
The overall grade for the subject will be calculated by weighting the grade of the different tests. As the following way:

Global grade = 0.15 × Lab practice grade + 0.85 × Exam grade

8.3 Single Final Evaluation:

8.3.1 Examinations Convocatory I

To benefit from the Single Final Evaluation, the student must notify the coordinator by email within the first two weeks of the beginning or within the two weeks following enrollment if this enrollment has occurred after the beginning of the subject. Outside the aforementioned deadlines, the student may only request the Single Final Evaluation for exceptional reasons (work reasons, illness or disability) that must be duly justified. For more information, you can consult the UHU Evaluation Regulations of March 13, 2019 (article 8).

Students under this system will be evaluated in a single academic act through the following tests:

- Theory test 25%. It will consist of several theoretical questions to be reasonably resolved.
- Problem test 60%. It will consist of several problems to solve numerically.
- Lab practice test 15%. It will consist of various theoretical and numerical questions related to the experiences developed in the laboratory sessions.

In order to pass the subject, it will be a requirement that the average global grade of the three tests is equal to or greater than 5, and that a minimum grade of 3.5 out of 10 has been obtained in each of them.

Students who carry out any type of activity (work, Lab practice or exam) from the beginning of the course without having expressly stated their intention to take advantage of the Single Final Assessment will be considered by default to take Continuous Evaluation and in no way may they be considered in the record as "Not presented".

8.3.2 Examinations Convocatory II

To benefit from the Single Final Evaluation, the student must notify the coordinator by email within the first two weeks of the beginning or within the two weeks following enrollment if this enrollment has occurred after the beginning of the subject. Outside the aforementioned deadlines, the student may only request the Single Final Evaluation for exceptional reasons (work reasons, illness or disability) that must be duly justified. For more information, you can consult the UHU Evaluation Regulations of March 13, 2019 (article 8).

Students under this system will be evaluated in a single academic act through the following tests:

- Theory test 25%. It will consist of several theoretical questions to be reasonably resolved.
- Problem test 60%. It will consist of several problems to solve numerically.
- Lab practice test 15%. It will consist of various theoretical and numerical questions related to the experiences developed in the laboratory sessions.

In order to pass the subject, it will be a requirement that the average global grade of the three tests is equal to or greater than 5, and that a minimum grade of 3.5 out of 10 has been obtained in each of them.

Students who carry out any type of activity (work, Lab practice or exam) from the beginning of the course without having expressly stated their intention to take advantage of the Single Final Assessment will be considered by default to take Continuous Evaluation and in no way may they be considered in the record as "Not presented".

8.3.3 Examinations Convocatory III

To benefit from the Single Final Evaluation, the student must notify the coordinator by email within the first two weeks of the beginning or within the two weeks following enrollment if this enrollment has occurred after the beginning of the subject. Outside the aforementioned deadlines, the student may only request the Single Final Evaluation for exceptional reasons (work reasons, illness or disability) that must be duly justified. For more information, you can consult the UHU Evaluation Regulations of March 13, 2019 (article 8).

Students under this system will be evaluated in a single academic act through the following tests:

- Theory test 25%. It will consist of several theoretical questions to be reasonably resolved.
- Problem test 60%. It will consist of several problems to solve numerically.
- Lab practice test 15%. It will consist of various theoretical and numerical questions related to the experiences developed in the laboratory sessions.

In order to pass the subject, it will be a requirement that the average global grade of the three tests is equal to or greater than 5, and that a minimum grade of 3.5 out of 10 has been obtained in each of them.

Students who carry out any type of activity (work, Lab practice or exam) from the beginning of the course without having expressly stated their intention to take advantage of the Single Final Assessment will be considered by default to take Continuous Evaluation and in no way may they be considered in the record as "Not presented".

8.3.4 Extraordinary Convocatory

To benefit from the Single Final Evaluation, the student must notify the coordinator by email within the first two weeks of the beginning or within the two weeks following enrollment if this enrollment has occurred after the beginning of the subject. Outside the aforementioned deadlines, the student may only request the Single Final Evaluation for exceptional reasons (work reasons, illness or disability) that must be duly justified. For more information, you can consult the UHU Evaluation Regulations of March 13, 2019 (article 8).

Students under this system will be evaluated in a single academic act through the following tests:

- Theory test 25%. It will consist of several theoretical questions to be reasonably resolved.
- Problem test 60%. It will consist of several problems to solve numerically.
- Lab practice test 15%. It will consist of various theoretical and numerical questions related to the experiences developed in the laboratory sessions.

In order to pass the subject, it will be a requirement that the average global grade of the three tests is equal to or greater than 5, and that a minimum grade of 3.5 out of 10 has been obtained in each of them.

Students who carry out any type of activity (work, Lab practice or exam) from the beginning of the course without having

expressly stated their intention to take advantage of the Single Final Assessment will be considered by default to take Continuous Evaluation and in no way may they be considered in the record as "Not presented".

ANEXO I

9. **Orientative weekly teaching organization:**

Date	Large Group	Small Group				Evaluating test	Contents
		Classrooms	Lab	Field work	Computing		
17/09/24	3	0	0	0	0		Lesson 1
24/09/24	3	0	0	0	0		Lesson 2
01/10/24	3	1,5	1,5	0	0	Attendance	Lesson 2
08/10/24	3	0	0	0	0		Lesson 3
15/10/24	3	0	0	0	0		Lesson 3
22/10/24	3	1,5	1,5	0	0	Attendance	Lesson 4
29/09/24	3	0	0	0	0		Lesson 5
05/11/24	3	0	0	0	0		Lesson 5
12/11/24	3	1,5	1,5	0	0	Attendance	Lesson 6
19/11/24	3	0	0	0	0		Lesson 6
26/11/24	3	1,5	1,5	0	0	Attendance	Lesson 7
03/12/24	3	0	0	0	0		Lesson 7
10/12/24	3	1,5	1,5	0	0	Attendance	Lesson 8
17/12/24	3	0	0	0	0		Lesson 9
TOTAL	45	7,5	7,5	0	0		