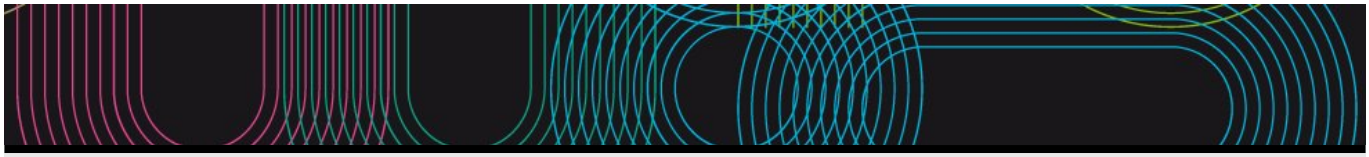

IDENTIFYING DATA				
Thermal engineering I				
Subject	Thermal engineering I			
Code	P52G381V01403			
Study programme	Grado en Ingeniería Mecánica			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Mandatory	4th	1st
Teaching language	English			
Department				
Coordinator	Cacabelos Reyes, Antón			
Lecturers	Cacabelos Reyes, Antón Febrero Garrido, Lara			
E-mail	acacabelos@cud.uvigo.es			
Web	http://moovi.uvigo.gal			
General description	This document shows the competences that the students must acquire with the course Advanced Thermodynamics. It contains the calendar with all the teaching activities, the syllabus, the time schedule, an estimation of the students working load and the evaluation criteria. This course, which is located in the fourth year of the mechanical engineering bachelor degree, explains the fundamentals of combustion, the mixture of air and water vapor and the main processes occurred in thermal systems.			

Training and Learning Results	
Code	
B1	Skills for writing, signing and developing projects in the field of industrial engineering, whose purpose is, specializing in Mechanics, construction, alteration, repair, maintenance, demolition, manufacturing, installation, assembly or operation of: structures, mechanical equipments, energy facilities, electrical systems and electronic installations and industrial plants, and manufacturing processes and automation.
C21	Knowledge applied to thermal engineering.
D1	Analysis and synthesis
D2	Problems resolution.
D6	Application of computer science in the field of study.
D8	Decision making.
D10	Self learning and work.
D14	Creativity.
D16	Critical thinking.
D17	Team working.

Expected results from this subject	Training and Learning Results		
Understanding the processes in which humid air is involved and managing of the psychrometric chart.	B1	C21	D1 D2 D10
Understanding the fundamentals of combustion.	B1	C21	D1 D2 D6 D10 D16 D17

Understanding the power production cycles.		C21	D1 D2 D6 D10 D14 D16
Ability to assess any basic thermal process.	B1	C21	D1 D2 D6 D8 D10 D14 D16 D17
To acquire basic knowledge about thermal machines.	B1	C21	D1 D2 D8 D10 D17
ENAEE learning outcome: KNOWLEDGE and UNDERSTANDING: LO1.2.- Knowledge and understanding of the mathematics and other basic sciences underlying their engineering specialisation, at a level necessary to achieve the other programme outcomes [Level of achievement (Basic (1), Intermediate (2) and Advanced (3)) for this learning outcome: Intermediate (2)].		C21	
ENAEE learning outcome: ENGINEERING ANALYSIS: LO2.1.- Awareness of the multidisciplinary context of the engineering [Intermediate (2)].	B1		D2 D8
ENAEE learning outcome: ENGINEERING ANALYSIS: LO2.2.- Ability to identify, formulate and solve engineering problems in their field of study; to select and apply relevant methods from established analytical, computational and experimental methods; to recognise the importance of non-technical societal, health and safety, environmental, economic and industrial constraints [Intermediate (2)].			D1 D2 D8 D14 D16
ENAEE learning outcome: ENGINEERING PROJECTS: LO3.1.- The ability to apply their knowledge to plan and carry out projects that meet previously specified requirements [Basic (1)].			D2
ENAEE learning outcome: RESEARCHING AND INNOVATION: LO4.3.- Ability to design and conduct experiments, interpret data and draw conclusions [Basic (1)].		C21	
ENAEE learning outcome: ENGINEERING PRACTICE: LO5.1.- Understanding of applicable techniques and methods of analysis, design and investigation and of their limitations in their field of study [Intermediate (2)].		C21	
ENAEE learning outcome: ENGINEERING PRACTICE: LO5.3.- Understanding of applicable materials, equipment and tools, engineering technologies and processes, and of their limitations in their field of study [Intermediate (2)].			D6 D8
ENAEE learning outcome: COMMUNICATION AND TEAM-WORKIN: LO7.2.- Ability to function effectively in a national and international context, as an individual and as a member of a team and to cooperate effectively with engineers and non-engineers [Basic (1)].	B1		D8 D10 D17

Contents

Topic	
BLOCK 1 (B1): Gas-vapor mixtures.	B1-1. Dry air and atmospheric air. Specific and relative humidity of the air. B1-2 Dew point temperature. Psychrometric charts. B1-3 Air conditioning.
BLOCK 2 (B2): Combustion and fuels properties.	B2-1. Fuels. Description and characteristics. Boilers and burners. B2-2 The combustion process. Theoretical and actual combustion. B2-3 Enthalpy of formation, enthalpy of combustion and heating values. B2-4 First-law analysis of reacting systems. B2-5 Second-law analysis of reacting systems.

BLOCK 3 (B3) Power production cycles.	B3-1 Gas power cycles I: Otto, Diesel, Stirling and Ericsson ideal cycles. Air standard cycles. B3-2 Gas power cycles II: Brayton cycle. Actual cycles. Intercooling reheating and regeneration. Ideal jet-propulsion cycles. B3-3 Vapor and combined power cycles: Rankine cycle. Actual vapor cycles. Reheating and regeneration. Open and closed feedwater heaters. B3-4 Combined gas-vapor power cycles.
BLOCK 4 (B4) Refrigeration cycles.	B4-1 Vapor-compression refrigeration systems: Actual cycles. Refrigerant properties. B4-2 Heat pumps. B4-3 Innovative vapor-compression refrigeration systems: Cascade refrigeration systems. Multistage compression refrigeration systems. Multipurpose refrigeration systems with a single compressor. B4-4 Gas refrigeration cycles. B4-5 Absorption refrigeration systems.

Practices of laboratory	PL 1. Introduction to thermal comfort and indoor air quality. The aim of this practice is to determine the air humidity in different indoor stays of buildings and in the outside. Besides, the concept of thermal comfort and indoor air quality are introduced, features that are related with the health and the welfare of the users of buildings. Equipment of measurement employed: hygrometers, sensors of temperature, measurers of quality of indoor air, etc. PL 2. Fuels and combustion. Boiler room of the students barracks building. A technical visit will be made to the boiler room of the Francisco Moreno barracks, which consists of two natural gas boilers and provides domestic hot water (DHW) and heating to the student barracks. The purpose of the visit is to identify the equipment involved in a heating system and learn how to make a simplified scheme of the installation. In addition, this practice includes the study of health and safety conditions in a boiler room: identification of risks, emergency measures, PRL, Legionella control, etc. PL 3. Development and presentation of works on social, health and security features related to Thermal Engineering. In this practice the students have to present the work developed during the first weeks of course. The works are proposed by the lecturers at the beginning of the course and they will be made by groups of 4 or 5 students. The subjects will treat on social, health and industrial security of related to Thermal Engineering. For example: energy efficiency in buildings, energy efficiency in ships, storage and transport of liquid fuels, maritime transport of fuels, thermal solar energy in buildings, renewable energies, cogeneration and trigeneration, etc. PL 4. Analysis of thermodynamic cycles with computer software. The practice consists of learning the use of computer tools for the simulation of power and refrigeration cycles (CYCLEPAD). The practice is oriented to solve problems of cycles (ideal and real) used in the most common thermal machines. PL 5. Stirling cycle analysis. An experimental Stirling engine is studied. Different variables that affect the operation of the engine, the cycle and the performance of the engine will be analyzed. The operation of the reverse cycle motor as a cooling machine will also be studied. PL 6. Experimental study of a heat pump In this practice the operation of a heat pump will be studied in an experimental facility. Energy balances will be carried out in each of its components to determine its coefficient of operation (COP), working both as a heating machine and as a cooling machine. Likewise, its behavior will be studied in operation as a water-water heat pump and as an air-water heat pump. PL 7. Introduction to the design of solar cooling installations. This is a theoretical and demonstrative practice on cooling production installations using solar thermal energy. The aim is for students to learn about an efficient alternative to the use of conventional equipment, whose refrigerants are highly harmful to the environment.

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	28	42	70
Laboratory practical	14	0	14
Seminars	7	7	14
Problem solving	26	26	52

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description

Lecturing	In these sessions, the lecturer will explain in detail the basic theoretical contents of the course, exposing clarifying examples that help to better understand the concepts. Computer presentations and the blackboard will be used, especially to transmit information like definitions, charts, algorithms, schematics etc.
Laboratory practical	Supervised laboratory and computer practices. The didactic method to be followed in the teaching of the practical classes consists in that the lecturer supervises the work and progress done by the different groups. The practices of laboratory are headed to strengthen the theoretical concepts tackled in the sessions in the classroom.
Seminars	In the seminars, the lecturer analyses and proposes a series of problems that have to make individually or in group. The student will have to solve exercises and problems under the supervision and correction of the lecturer.
Problem solving	Intensive course of 15 hours for those students that have failed the subject in first announcement, previous to the examination in second announcement. Tutorships in groups with the lecturer. Realisation of examinations. Tasks of evaluation and hours of reinforcement.

Personalized assistance

Methodologies	Description
Lecturing	Attention to student will be personalized both in the office hours and through email. Tutorial actions can be classified into academic or personalized tutoring. In the first case, students will have available office hours in which they can ask any questions regarding the contents, organization and planning of the course. Tutoring can also be individualized, but solving problems related to the activities carried out in groups will be encouraged. In personalized tutoring, each student, individually, can discuss with the lecturer any problem that is blocking an adequate progress in the course, in order to find some kind of solution. Combining both types of action tutorial students are intended to compensate for the different rates of learning through attention to diversity. The lecturers will personally answer the questions and queries of the students, both in person, according to the timetable that will be published on the center's website, and by telematic means (e-mail, videoconference, Moovi forums, etc.) by appointment.
Problem solving	Attention to student will be personalized both in the office hours and through email. Tutorial actions can be classified into academic or personalized tutoring. In the first case, students will have available office hours in which they can ask any questions regarding the contents, organization and planning of the course. Tutoring can also be individualized, but solving problems related to the activities carried out in groups will be encouraged. In personalized tutoring, each student, individually, can discuss with the lecturer any problem that is blocking an adequate progress in the course, in order to find some kind of solution. Combining both types of action tutorial students are intended to compensate for the different rates of learning through attention to diversity. The lecturers will personally answer the questions and queries of the students, both in person, according to the timetable that will be published on the center's website, and by telematic means (e-mail, videoconference, Moovi forums, etc.) by appointment.
Laboratory practical	Attention to student will be personalized both in the office hours and through email. Tutorial actions can be classified into academic or personalized tutoring. In the first case, students will have available office hours in which they can ask any questions regarding the contents, organization and planning of the course. Tutoring can also be individualized, but solving problems related to the activities carried out in groups will be encouraged. In personalized tutoring, each student, individually, can discuss with the lecturer any problem that is blocking an adequate progress in the course, in order to find some kind of solution. Combining both types of action tutorial students are intended to compensate for the different rates of learning through attention to diversity. The lecturers will personally answer the questions and queries of the students, both in person, according to the timetable that will be published on the center's website, and by telematic means (e-mail, videoconference, Moovi forums, etc.) by appointment.
Seminars	Attention to student will be personalized both in the office hours and through email. Tutorial actions can be classified into academic or personalized tutoring. In the first case, students will have available office hours in which they can ask any questions regarding the contents, organization and planning of the course. Tutoring can also be individualized, but solving problems related to the activities carried out in groups will be encouraged. In personalized tutoring, each student, individually, can discuss with the lecturer any problem that is blocking an adequate progress in the course, in order to find some kind of solution. Combining both types of action tutorial students are intended to compensate for the different rates of learning through attention to diversity. The lecturers will personally answer the questions and queries of the students, both in person, according to the timetable that will be published on the center's website, and by telematic means (e-mail, videoconference, Moovi forums, etc.) by appointment.

Assessment

	Description	Qualification	Training and Learning Results

Lecturing	A final test of continuous evaluation will be done during the evaluation week and will be graded over 10 points. A minimum grade of 4 points in this exam will be necessary to pass the subject in the continuous evaluation. This proof will have a weight of 40% of the grade of continuous evaluation. Two partial exams of continuous evaluation will be done, which will suppose 30% of the grade of continuous evaluation (15% each one of them).	70	B1 C21	D1 D2 D8 D10 D14 D16
Laboratory practical	Lab practices will be performed in small groups. Each group will have to deliver a memory of practices at the end of each practice, or group of practices. The memories of practices will have a weight of 10% of the grade of continuous evaluation.	10	B1 C21	D1 D2 D6 D8 D10 D14 D16 D17
Seminars	A group work will be done about social, health and industrial security features related to Thermal Engineering, that will be presented by the students in the practice 3 of the subject. The group work will have a weight of 10% of the grade of continuous evaluation.	10	B1 C21	D1 D2 D8 D10 D14 D16 D17
Problem solving	Seminars will be graded through individual or group tests or resolution of exercises performed in some of the seminar sessions when the lecturer request. These will mean 10% of the final grade.	10	B1 C21	D1 D2 D8 D14 D16 D17

Other comments on the Evaluation

The evaluation will be considered positive when a score of 5 is reached for the continuous evaluation. The students must attend the ordinary exam, which addresses the whole subject contents, if the total grade of continuous evaluation is lower than 5. They also will have to attend the ordinary exam if any of the following cases happens:

- Any of the tests or exams is missed.

- A grade lower than 4 points in the final theory exam is obtained.

For these cases, the continuous evaluation grade will be the minimum of 4 points and total continuous evaluation grade. In any case, the student who has passed the continuous evaluation, will be allowed to attend to the ordinary exam to increase the grade.

ACADEMIC INTEGRITY: Students are expected to show adequate ethical behaviour, committing to act honestly. Based on article 42.1 of the *Regulation on the evaluation, qualification and quality of teaching and the student learning process of the University of Vigo*, as well as point 6 of the fifth rule of *Order DEF/711/2022, of July 18th, which establishes the requirements for evaluation, progress, and ongoing enrolment in military educational training centres for incorporation into the ranks of the Armed Forces,* **any violation of academic integrity in the assessment process, as well as the cooperation in it will result in the assignment of a failing grade to the student (zero) for the entire course in the corresponding assessment opportunity,** regardless of the percentage of importance that the test in question had in the overall continuous assessment and independently of other disciplinary actions that may be applied.

Sources of information

Basic Bibliography

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Complementary Bibliography

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Wark, K., Richards, D.E., **Termodinámica**, 6ª edición, Mc Graw-Hill, 2001

Haywood, R.W., **Ciclos termodinámicos de potencia y refrigeración**, Limusa, 2000

Segura, J., **Termodinámica Técnica**, Reverte, 1988

Baehr, H.D., **Tratado moderno de termodinámica**, Tecnilibro, 1987

Kreith, F., Bohn, M.S., **Principios de Transferencia de Calor**, 6ª edición, Thomson, 2002

Holman, J.P., **Transferencia de Calor**, 8ª edicióm, Mc Graw-Hill, 1998

Agüera Soriano, J., **Termodinámica Lógica y Motores Térmicos**, Ciencia 3,

Chapman, A.J., **Transmisión de Calor**, 3ª edición, Bellisco, 1990
Segura, J., Rodríguez, J., **Problemas de Termodinámica Técnica**, Reverte, 1990
Lacalle, Nieto, **Problemas de Termodinámica**, Serv Pub. ETSII Madrid,
Aguirrezabalaga, V., **Transferencia de Calor: Problemas**, Serv Pub. Oviedo, 2006
Vázquez, M, **Problemas Resueltos de Termodinámica Técnica**, Serv Pub. Universidad de Vigo,

Recommendations

Subjects that continue the syllabus

Naval engines and machines/P52G381V01409

Other comments

It is strongly recommended to review the "Thermodynamics and heat transfer" course, especially those topics related to energy balances, thermal properties of materials and ideal gases behavior. It is also recommended to review the chemical reactions fundamentals.