1. BASIC INFORMATION

Course	Propulsion systems
Degree program	Degree in Aerospace Engineering of Aircraft
School	Escuela de Arquitectura, Ingeniería y Diseño
Year	4
ECTS	6 ECTS
Credit type	Compulsory
Language(s)	English
Delivery mode	Face-to-face
Semester	First
Academic year	2023/2024
Coordinating professor	Rafael Pax

2. PRESENTATION

This subject belongs to the "Moto propulsion I" module:

- Thermodynamics and heat transfer (6 ECTS, second year)
- Fluid mechanics I (6 ECTS, second year)
- Propulsion systems (6 ECTS, fourth year)

3. COMPETENCIES AND LEARNING OUTCOMES

Core competencies:

- CB1: That students have demonstrated knowledge and understanding in a field of study that part of the basis of general secondary education, and is usually found at a level that, while supported by advanced textbooks, includes some aspects that will knowledge of the forefront of their field of study.
- CB2: That students can apply their knowledge to their work or vocation in a professional manner and have competences typically demonstrated through devising and sustaining arguments and solving problems within their field of study.
- CB3: That students have the ability to gather and interpret relevant data (usually within their field of study) to make judgments that include reflection on relevant social, scientific or ethical.
- CB4: To allow students to communicate information, ideas, problems and solutions both to a specialized and non-specialized audience.
- CB5: That students have developed those learning skills necessary to undertake further studies with a high degree of autonomy.

Cross-curricular competencies:

- CT12: Knowledge of basic subjects and technologies, enabling the student to learn new methods, theories and technologies, and endowed it with great versatility to adapt to new situations (autonomous learning).
- CT14: Problem Solving with initiative, decision making, creativity, and critical thinking, professionally, and the preparation and defense of arguments (Troubleshooting).
- CT15: Compile and interpret data to make judgments that include relevant social, scientist, and ethical issues, taking fundamental rights respect into consideration, as well as the democratic principles, gender equality, solidarity, environment protection, universal accessibility and design for all, and culture of peace (consultancy).
- CT16: To communicate and convey information, ideas and skills in the student's field of specialization, either in writing or orally, both to skilled and unskilled audiences (communication skills).
- CT18: Commit to the fulfillment of the tasks (Responsibility).
- CT20: Take decisions, in advance, on what is need to be done, who should do it, and how it should be done.

Specific competencies:

- CE8: To understand thermodynamics cycles for mechanic power generation and thrust.
- CE16: Appropriate knowkedge applied to engineering of: concepts and laws that manage the processes of energy transfer, the movement of fluids, the mechanisms of heat transfer and mass exchange, and their influence on main systems of aerospace propulsion.
- CE18: Appropriate knowkedge applied to engineering of: basics of fluid mechanics; basic principles of flight control and automatitation; main characteristics and phisical and mechanical properties of materials.
- CE19: Applied knowledge of: the science and technology of materials, mechanics and thermodynamics, fluid mechanics, aerodynamics and flight mechanics, navigation and air traffic, aerospace technology, theory of structures, air transport, economy and production projects; impact on environment.

Learning outcomes:

- LO20: To conduct studies by integrating the technologies and engineering procedures which are developed in the competencies of this modules.
- LO21: to conceptualize an engineering problem, proposes an approach to solve it, and obtain the better solution. All this related to the competencies of this module.
- LO22: To transfer some parts of an engineering problem to the laboratory, and utilize this resource as support to resolve it.
- LO24: To propose and design a set of models, as input data to fluid dynamics simulators.

The following table shows the relationship between the competencies developed during the course and the learning outcomes pursued:

Competencies	Learning outcomes
B1, CB2, CB3, CB4, CB5	LO20, LO21, LO22, LO24
CT12, CT14, CT15, CT16, CT18, CT20	LO20, LO21, LO22, LO24
CE8, CE16, CE18, CE19	LO20, LO21, LO22, LO24

4. CONTENT

1. Generalities
    a. Classification of propulsion systems.
    b. Review of basic laws of Thermodynamics and Fluid Mechanics. Fundamental equations, one dimensional compressible flow. Shock waves. Nozzles.
2. Thrust generation
    a. Thrust, thermal and propulsive efficiencies.
    b. Propellers. Overview, Actuator disk theory
3. Introduction to alternative engines
    a. Types of aeropiston engines. Typical main parts description, mission and use.
    b. Aerodynamics and thermodynamics of reciprocating internal combustion engines.
    c. Terminology, air standard analysis, engine cycles. Otto cycle. Diesel Cycle
4. Introduction to jet engines. aeronautics and gas turbine design basics
    a. Main types of aeroengines. Turbojet, turbofan, Gas Turbine, Ramjet, Pulsejet
    b. Brayton cycle. Performance analysis
    c. Thrust augmentation methods
5. Resolution of problems of use, selection and performance of components.
    a. Compressors. Types. Advantages and disadvantages. Surge. Compressor map
    b. Turbines. Cooling. Turbine map
    c. Exhaust nozzle Fixed and variable
    d. Air intakes Subsonic and supersonic
    e. Combustors
6. Introduction to rocket engines. Fundamentals of rocket engines and micro-rocket engines.
    a. Introduction. Rocket description. Classification. Microrockets
    b. Rocket performance parameters
    c. Chemical rockets. Solid and liquid propellant
    d. Hybrid propulsion.
    e. Nuclear and electrical rockets

5. TEACHING-LEARNING METHODOLOGIES

The types of teaching-learning methodologies used are indicated below:

- Survey of objectives and interests
- Master class
- Laboratory practices
- Research by groups or problem solving by groups
- Simulation

6. LEARNING ACTIVITIES

Listed below are the types of learning activities and the number of hours the student will spend on each one:

Campus-based mode:

Learning activity	Number of hours

Lecture-based class	40
Integrative team work at class	20
Self-study	50
Mentoring, academic monitoring and assessment	20
Homework, Assugnments,	20
TOTAL	**150**

7. ASSESSMENT

Listed below are the assessment systems used and the weight each one carries towards the final course grade:

Campus-based mode:

Assessment system	Weight
Exam, test and other type of assessment.	30%-35%
Reports, articles and informs. Assignments	20%
Alternative system of assessment.	10%
Conferences, company-tour visit and experiences in situ	10%
Transversal skills	10%

When you access the course on the *Campus Virtual*, you'll find a description of the assessment activities you have to complete, as well as the delivery deadline and assessment procedure for each one.

7.1. First exam period

To pass the course in the first exam period, you must obtain a final course grade of at least 5 out of 10 (weighted average).

In any case, you will need to obtain a grade of at 5.0 in the final exam in order for it to count towards the final grade along with all the grades corresponding to the other activities.

7.2. Second exam period

To pass the course in the second exam period, you must obtain a final grade of at least 5 out of 10 (weighted average).

In any case, you will need to obtain a grade of at 5.0 in the final exam in order for it to count towards the final grade along with all the grades corresponding to the other activities.

The student must deliver the activities not successfully completed in the first exam period after having received the corresponding corrections from the professor, or those that were not delivered in the first place.

8. SCHEDULE

This table shows the delivery deadline for each assessable activity in the course:

Assessable activities	Deadline
Units 1 to 3 exam	19-0ct-2022
Unit 4 to 5 exam	30-Nov-2022
Unit 6 Exam	16-jan 2023
Assignments	1 week after proposed
Final Exam	23-jan-2023

This schedule may be subject to changes for logistical reasons relating to the activities. The student will be notified of any change as and when appropriate.

9. BIBLIOGRAPHY

The main reference work and bibliography for this subject is:

- Fundamentals of Aircraft and Rocket propulsion. Ahmed F.El Sayed. Springer
- Rolls Royce, The Jet engine
- Mechanics and thermodynamics of propulsion. Phillip Hill-Carl Peterson. Addison Wesley

In addition to that there will be access to

- Class notes
- Guidelines
- Exercises solutions
- Virtual campus contents

10. DIVERSITY MANAGEMENT UNIT

Students with specific learning support needs:

Curricular adaptations and adjustments for students with specific learning support needs, in order to guarantee equal opportunities, will be overseen by the Diversity Management Unit (UAD: Unidad de Atención a la Diversidad).

It is compulsory for this Unit to issue a curricular adaptation/adjustment report, and therefore students with specific learning support needs should contact the Unit at unidad.diversidad@universidadeuropea.es at the beginning of each semester.

11. ONLINE SURVEYS

Your opinion matters!

The Universidad Europea encourages you to participate in several surveys which help identify the strengths and areas we need to improve regarding professors, degree programs and the teaching-learning process.

The surveys will be made available in the “surveys” section in virtual campus or via e-mail.

Your assessment is necessary for us to improve.

Thank you very much for your participation.