Space Propulsion

Academic Year: (2023 / 2024) **Review date: 19-05-2023**

Department assigned to the subject: Aerospace Engineering Department

Coordinating teacher: AHEDO GALILEA, EDUARDO ANTONIO

Type: Compulsory ECTS Credits : 3.0

Year : 1 Semester : 1

REQUIREMENTS (SUBJECTS THAT ARE ASSUMED TO BE KNOWN)

Complements of Aerospace Engineering

OBJECTIVES

Basic competences

CB6 To possess and understand knowledge that provides a basis or opportunity to be original in the development and / or application of ideas, often in a research context
CB7 Students must know how to apply the knowledge acquired and their ability to solve problems in new or unfamiliar environments within broader (or multidisciplinary) contexts related to their area of study
CB8 Students must be able to integrate knowledge and face the complexity of making judgments based on information that, being incomplete or limited, includes reflections on social and ethical responsibilities linked to the application of their knowledge and judgments
CB9 Students must know how to communicate their conclusions and the knowledge and ultimate reasons that sustain them to specialized and non-specialized audiences in a clear and unambiguous way
CB10 Students must have the learning skills allowing them to continue studying in a way that will be largely self-directed or autonomous.

General competences

CG1 Capacity for the formulation, critical verification and defense of hypotheses, as well as the design of experimental tests for verification.
CG2 Ability to make value judgments and prioritize in making conflicting decisions using systemic thinking.
CG4 Ability to work in multidisciplinary teams in a cooperative way to complete work tasks
CG5 Ability to handle the English, technical and colloquial language.

Specific competences

CE3 Ability to develop a complete system that meets the design specifications and the expectations of the interested parties. This includes the production of products; acquire, reuse or code products; integrate products in top-level assemblies; verify products against design specifications; validate the products against the expectations of the interested parties; and the transition of products to the next level of the system.

CE9 Ability to understand and apply the knowledge, methods and tools of space engineering to the analysis and design of the propulsion subsystem of space vehicles.

DESCRIPTION OF CONTENTS: PROGRAMME

1. IN-SPACE PROPULSION
Propulsion figures of merit: thrust, specific impulse, efficiencies.
Propulsive requirements in space missions. Rocket equation.
Chemical versus electric propulsion
Optimum specific impulse
Electric propulsion technologies
Missions with electric propulsion

2. CHEMICAL PROPULSION IN SPACE
Figures of merit in chemical rockets (nozzles): thrust coefficient, characteristic velocity, etcetera.
Monopropellant rockets: cold gas and hydrazine-based rockets.
Bipropellant rockets: analysis of fuels and oxidizers. Review of thermochemistry.

3. ELECTRIC PROPULSION: PHYSICAL PRINCIPLES
Operation principles of Ion and Hall Thrusters.
Maxwell and Fluid equations.
Quasineutrality, Debye sheaths, and plasma wall interaction.
Collisional processes.
Dynamics of magnetized populations.
Generalized Ohm¿s and Fourier¿s laws.

4. GRIDDED ION THRUSTERS
Thruster elements and electrical configuration.
Global model of the discharge chamber: current and power balances.
Grid model: Child¿s model and optimal perveance
Model of expansion of the plasma jet.
Performance laws and efficiencies.
Physics of the hollow cathode: thermionic emission.
Thruster lifetime.

5. HALL EFFECT THRUSTERS
Plasma discharge structure and operational parameters.
Global model: current and energy balances, efficiencies.
Axial and radial fluid models: electron transport, interaction with walls.
Technological aspects: chamber erosion, thermal loads, oscillations, magnetic circuit and topology.
Alternative configurations.

LEARNING ACTIVITIES AND METHODOLOGY

AF1 Theoretical class
AF2 Practical classes
AF3 Practices in computer classroom
AF4 Laboratory practices
AF6 Group work
AF7 Individual student work
AF8 Evaluation activities

Code activity	Nº Total hours	Nº HoursPresencial	% Student's presence
AF1	103	103	100
AF2	45	45	100
AF3	28	28	100
AF4	14	14	100
AF6	67	0	0
AF7	400	0	0
AF8	24	24	100
TOTAL SUBJECT	682	215	32

Teaching methodologies that will be used in this subject

MD1 Exhibitions in the teacher's class with support of computer and audiovisual media, in which the main concepts of the subject are developed and the bibliography is provided to complement the students' learning.

MD3 Resolution of practical cases, problems, etc. raised by the teacher individually or in groups

MD5 Preparation of papers and reports individually or in groups

ASSESSMENT SYSTEM

EVALUATION SYSTEMS:

ASSESSMENT SYSTEMS OF THE STUDY PLAN REFERRED TO SUBJECTS

SE2 Individual or group work carried out during the course

SE3 Final exam

System of Evaluation	Minimum weight (%)	Maximum weight (%)
SE2	40%	100%
SE3	0%	60%

In order to pass the subject in the ordinary call, two requirements need to be met:
1) to have a MINIMUM mark of 4.0 over 10 in the end-of-term exam;
2) to have a minimum overall mark of 5.0 over 10 (weighing 60% the end-of-term exam mark and 40% the mark of the continuous evaluation).

% end-of-term-examination:	60
% of continuous assessment (assigments, laboratory, practicals…):	40

BASIC BIBLIOGRAPHY

- D. GOEBEL, I. KATZ FUNDAMENTALS OF ELECTRIC PROPULSION, WILEY , 2008
- G. Sutton and O. Biblarz, Rocket Propulsion Elements, , Wiley, , 2010.

ADDITIONAL BIBLIOGRAPHY

- M. J. L. Turner Rocket and Spacecraft Propulsion, Springer, 2006
- R. JAHN PHYSICS OF ELECTRIC PROPULSION, DOVER, 2006