Advanced Space Propulsion

Academic Year: (2023 / 2024) **Review date: 19/05/2023 14:49:27**

Department assigned to the subject: Aerospace Engineering Department

Coordinating teacher: AHEDO GALILEA, EDUARDO ANTONIO

Type: Compulsory ECTS Credits : 3.0

Year : 2 Semester : 1

REQUIREMENTS (SUBJECTS THAT ARE ASSUMED TO BE KNOWN)

Design of Space Systems

OBJECTIVES

The course is focused on Electric Space Propulsion, as the new leading technology for in-space propulsion both in Near-Earth and Inner-Solar system applications.

The goals of the course are that the students acquire a solid understanding of

- the benefits and limitations of electric rocket propulsion versus classical chemical rocket propulsion, for different missions, and from microsatellites to large platforms.
- the different types of electric thrusters and their main principles of operations
- the main plasma physics concepts inherent to these thrusters
- the derivation of performance models to support design, testing, and optimization of these technologies
- the main technological constraints found in practice

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

They combine
- lectures with audiovisual support
- discussion and solving of exercises and problems
- homework assignements
- quizzes

Tutorials can be both personally or through Aula Global

ASSESSMENT SYSTEM

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

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).

BASIC BIBLIOGRAPHY

- D. GOEBEL, I. KATZ FUNDAMENTALS OF ELECTRIC PROPULSION, WILEY, 2008

- R. JAHN PHYSICS OF ELECTRIC PROPULSION, DOVER, 2006