

Academic Year: ( 2017 / 2018 )

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Department assigned to the subject: Bioengineering and 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 primarily in Space Electric Propulsion, as an emerging technology for spacecraft propulsion both in Near-Earth and Deep-Space applications.

The goals of the course are to provide skills that allow students understanding of

- the benefits and limitations of electric rocket propulsion versus classical chemical rocket propulsion, for different missions scenarios
- the different electric propulsion devices and their main principles of operations
- basic notions of plasmas with application to the physics of electric thrusters
- performances and testing
- design and operational parameters and technological constraints

Additionally the course includes a lesson devoted to present briefly the operational principles, physics, performances and applications of ramjets and scramjets.

**DESCRIPTION OF CONTENTS: PROGRAMME****1. FUNDAMENTALS OF ELECTRIC PROPULSION**

Figures of merit for propulsion.  
 Specific thrust versus specific impulse.  
 Chemical versus electric propulsion(EP).  
 Optimal specific impulse.  
 Missions for EP: main types, historical milestones.  
 Plasma generation and acceleration mechanisms.  
 The EP family of thrusters: brief presentation of prototypes.

**2. BASIC NOTIONS OF PLASMA PHYSICS**

Maxwell equations. On plasma typical units.  
 Quasineutrality. Debye sheaths and plasma-surface interaction.  
 The velocity distribution function and Boltzmann equation.  
 Multifluid formulations.  
 Main collisional processes (elastic, ionizing, Coulomb, CEX).  
 Magnetized particle dynamics.  
 Magnetized fluid dynamics: generalized Ohm and Fourier laws.

**3. GRIDDED ION THRUSTERS**

Principles of operation: discharge chamber, grids, hollow cathode.  
 The electric circuit.  
 Global model of discharge chamber:  
 plasma production,

current and power balances, magnetic confinement.  
Inter-grid physics; the Child law.  
Plasma plume expansion.  
Performance laws.  
Thermionic emission.  
Hollow cathode physics.  
Thruster lifetime

#### 4. HALL EFFECT THRUSTERS

Principles of operation.  
Experimental characterization.  
The 2D multifluid formulation.  
Anomalous diffusion.  
Anode sheath.  
Secondary electron emission at ceramic walls.  
The simplified 1D model: formulation and solution.  
Global performance analysis and thrust mechanisms.  
Wall sputtering.  
Thermal loads. Plasma and circuit oscillations.  
Design of magnetic circuit.  
Alternative configurations (TAL, cylindrical, two-stage, HEMP)

#### 5. ADVANCED PLASMA THRUSTERS

Magnetoplasmadynamic thruster (with self and applied fields)  
The helicon plasma thruster: RF production and magnetic nozzle acceleration.

### LEARNING ACTIVITIES AND METHODOLOGY

They combine

- lectures with audiovisual support
- discussion and solving of exercises and problems
- homework assignments
- quizzes

Tutorials can be both personally or through Aula Global

### ASSESSMENT SYSTEM

<b>% end-of-term-examination/test:</b>	60
<b>% of continuous assessment (assignments, laboratory, practicals...):</b>	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