

Course guides

19613 - ANP - Architecture of Nano and Picosatellites

Last modified: 27/05/2019

Unit in charge: Castelldefels School of Telecommunications and Aerospace Engineering
Teaching unit: 748 - FIS - Department of Physics.

Degree: MASTER'S DEGREE IN AEROSPACE SCIENCE AND TECHNOLOGY (Syllabus 2015). (Optional subject).

Academic year: 2019 **ECTS Credits:** 5.0 **Languages:** English

LECTURER

Coordinating lecturer: Defined in the course webpage at the EETAC website.

Others: Defined in the course webpage at the EETAC website.

PRIOR SKILLS

This subject requires knowledge of Physics, Mathematics, and Engineering. It would be highly desirable to have been enrolled in the topic on "Spacecraft Systems Engineering". Basic knowledge of Matlab/Octave is also required.

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:

CE3 MAST. (ENG) CE3: Aplicar los métodos numéricos para ingeniería aeroespacial con especial énfasis en sus aplicaciones, y en especial en la dinámica de fluidos.

CE4 MAST. (ENG) CE4: Aplicar el método científico para el estudio de la fenomenología particular del ambiente aeroespacial.

CE5 MAST. (ENG) CE5: Aplicar la ingeniería de sistemas en el entorno aeroespacial para el diseño y la gestión de los distintos aspectos tecnológicos asociados a una misión.

Generical:

CG1 MAST. (ENG) CG1: Identificar y conocer las principales actividades de I+D+i en el campo aeroespacial que se llevan a cabo actualmente a nivel internacional en el ámbito académico, la industria y las mayores agencias espaciales.

CG2 MAST. (ENG) CG2: Identificar y aplicar los análisis teóricos, experimentales y numéricos fundamentales de uso actual en ingeniería aeroespacial.

Transversal:

CT2. SUSTAINABILITY AND SOCIAL COMMITMENT: Being aware of and understanding the complexity of the economic and social phenomena typical of a welfare society, and being able to relate social welfare to globalisation and sustainability and to use technique, technology, economics and sustainability in a balanced and compatible manner.

CT3. TEAMWORK: Being able to work in an interdisciplinary team, whether as a member or as a leader, with the aim of contributing to projects pragmatically and responsibly and making commitments in view of the resources that are available.

CT4. EFFECTIVE USE OF INFORMATION RESOURCES: Managing the acquisition, structuring, analysis and display of data and information in the chosen area of specialisation and critically assessing the results obtained.

CT5. FOREIGN LANGUAGE: Achieving a level of spoken and written proficiency in a foreign language, preferably English, that meets the needs of the profession and the labour market.

Basic:

CB7. (ENG) CB7 - Que los estudiantes sepan aplicar los conocimientos adquiridos y su capacidad de resolución de problemas en entornos nuevos o poco conocidos dentro de contextos más amplios (o multidisciplinares) relacionados con su área de estudio.

CB8. (ENG) CB8 - Que los estudiantes sean capaces de integrar conocimientos y enfrentarse a la complejidad de formular juicios a partir de una información que, siendo incompleta o limitada, incluya reflexiones sobre las responsabilidades sociales y éticas vinculadas a la aplicación de sus conocimientos y juicios.

TEACHING METHODOLOGY

This topic will be based on lectures in the classroom. The PowerPoint presentations will be available from the very beginning, as well as some relevant software and other information.

Teamwork is will be mandatory along the course since the students will engage on a Phase A design of a space mission to be performed by means of a nano or picosatellite.

We will apply the following teaching methodologies:

MD1: Master class

MD2: Participatory expositive class

MD4: Problem / project based learning

MD5: Autonomous work

MD6: cooperative work

LEARNING OBJECTIVES OF THE SUBJECT

At the end of the topic, students will be able to identify, analyze and write the requirements of a space mission to be undertaken by means of a small satellite (less than a few tens of kilograms). They will also be able to predict the environmental conditions for the mission and to perform a phase A design of the satellite, including its configuration, structure, power, attitude determination and control, onboard computer, thermal control, and communications subsystems, as well as the tests required to ensure that the different subsystems will perform as expected. Students will know and apply the main methods for preliminary cost determination.

We will make special emphasis on the differences between small satellite and standard satellite engineering.

STUDY LOAD

| Type | Hours | Percentage |
|-------------------|-------|------------|
| Hours large group | 45,0 | 100.00 |

Total learning time: 45 h

CONTENTS

Introduction

Description:

1. A short history of Small Satellites
2. Why small?
3. Basics of Spacecraft Systems Engineering

Related activities:

AFP1: Exposition of theoretical contents through lectures.
AFP7: Attendance at seminars and conferences related to the subject matter.
AFP8: Tutoring.

Related competencies :

CG2 MAST. (ENG) CG2: Identificar y aplicar los análisis teóricos, experimentales y numéricos fundamentales de uso actual en ingeniería aeroespacial.

CE5 MAST. (ENG) CE5: Aplicar la ingeniería de sistemas en el entorno aeroespacial para el diseño y la gestión de los distintos aspectos tecnológicos asociados a una misión.

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Full-or-part-time: 3 h

Theory classes: 1h

Self study : 2h

Space Environment

Description:

1. Microgravity
2. The neutral medium. The high atmosphere
3. The ionized environment and the magnetosphere
4. The effects of vacuum
5. Ionizing radiation
6. Micrometeoroids and space debris

Full-or-part-time: 11 h

Theory classes: 3h

Practical classes: 1h

Self study : 7h



Small satellite launchers

Description:

1. Rocket basics
2. Piggyback launches
3. Small launchers

Full-or-part-time: 9 h

Theory classes: 3h

Practical classes: 1h

Self study : 5h

Systems Engineering

Description:

1. What is Systems Engineering?
2. Spacecraft Design Process
3. Concurrent Design
4. On-orbit failure analysis

Full-or-part-time: 7 h

Theory classes: 2h

Practical classes: 1h

Self study : 4h

Structure

Description:

1. Satellite configuration
2. Primary and Secondary Structure
3. Shaker tests
4. Materials
5. 3D printed structures

Full-or-part-time: 11 h

Theory classes: 3h

Practical classes: 1h

Self study : 7h

Power Subsystem

Description:

1. Power bus types: non-regulated, quasi-regulated, regulated
2. Photovoltaic systems
3. Batteries
4. Fuel cells

Full-or-part-time: 11 h

Theory classes: 3h

Practical classes: 1h

Self study : 7h



Communications

Description:

1. Communications basics. The link equation
2. Antennae
3. Receivers and transceivers
4. Signal modulation
5. Ground stations
6. Software Defined Radio

Full-or-part-time: 11 h

Theory classes: 3h

Practical classes: 1h

Self study : 7h

Tracking, Telemetry, and Commands

Description:

1. Commands
2. Error correcting techniques
3. Telemetry standards

Full-or-part-time: 5 h

Theory classes: 1h 30m

Practical classes: 0h 30m

Self study : 4h 30m

Thermal control

Description:

1. Energy transport mechanisms
2. Optical properties of surfaces
3. Thermal balance equation
4. Passive thermal control systems
5. Active thermal control systems
6. Tests on thermal vacuum chambers

Full-or-part-time: 11 h

Theory classes: 3h

Practical classes: 1h

Self study : 7h

Onboard computer

Description:

1. Radiation effects
2. Processors
3. Memory
4. Data storage
5. Communication buses: I2C, SpaceWire

Full-or-part-time: 6 h

Theory classes: 2h

Practical classes: 0h 30m

Self study : 4h 30m



Attitude Determination and Control

Description:

1. Basic Mechanics. Inertia tensor and Euler equations
2. Attitude representations
3. Classification of satellites: non-stabilised, spinners, duals spinners, momentum bias, three-axis stabilised
4. Attitude sensors
5. Attitude actuators

Full-or-part-time: 11 h

Theory classes: 3h

Practical classes: 1h

Self study : 7h

Propulsion

Description:

1. Cold gas thrusters
2. Chemical rockets
3. Electric engines
4. Electromagnetic engines
5. Solars sails

Full-or-part-time: 11 h

Theory classes: 3h

Practical classes: 1h

Self study : 7h

Tests

Description:

1. Integration
2. Reliability statistics. The Weibull distribution
3. Testing

Full-or-part-time: 5 h

Theory classes: 1h 30m

Practical classes: 0h 30m

Self study : 4h

Cost analysis

Description:

1. Cost options
2. Parametric and non-parametric determinations
3. Cost reduction techniques

Full-or-part-time: 5 h

Theory classes: 1h

Practical classes: 0h 30m

Self study : 4h



Legal issues

Description:

1. The UN space treaties
2. Insurance and liability
3. National regulations
4. Launch license
5. Communications and the ITU

Full-or-part-time: 4 h

Theory classes: 1h

Self study : 3h

GRADING SYSTEM

Defined in the course webpage at the EETAC website.

BIBLIOGRAPHY

Basic:

- Helvajian, Henry; Janson, Siegfried W. Small satellites : past, present, and future. First edition. El Segundo, Calif. : Reston, Va.: Aerospace Press ; American Institute of Aeronautics and Astronautics, [2008]. ISBN 9781884989223.
- Fundamentals of space systems. 2nd ed. Oxford: Oxford University Press, 2005. ISBN 0195162056.
- Wertz, James Richard. Space Mission Engineering: the new SMAD. Mcgraw-Hill, 2011. ISBN 9781881883159.
- Helvajian, Henry. Microengineering aerospace systems. El Segundo, Calif.: Aerospace Press, cop. 1999. ISBN 1884989039.

Complementary:

- Pisacane, Vincent L. The Space environment and its effects on space systems. First edition. Reston, Va.: American Institute of Aeronautics and Astronautics, [2008]. ISBN 9781563479267.
- Wertz, James Richard; Larson, Wiley J. Reducing space mission cost. Torrance, Calif. : Dordrecht ; Boston: Microcosm Press ; Kluwer Academic Publishers, cop. 1996. ISBN 0792340213.