Last update: 25-10-2018

19613 - ANP - Architecture of Nano and Picosatellites

Coordinating unit: 300 - EETAC - Castelldefels School of Telecommunications and Aerospace Engineering

Teaching unit: 748 - FIS - Department of Physics

Academic year: 2018

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

ECTS credits: 5 Teaching languages: English

Teaching staff

Coordinator: 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

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.

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.

19613 - ANP - Architecture of Nano and Picosatellites

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.

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

Total learning time: 45h	Hours large group:	45h	100.00%

Last update: 25-10-2018

19613 - ANP - Architecture of Nano and Picosatellites

Content

Introduction

Learning time: 3h

Theory classes: 1h
Self study : 2h

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.

Space Environment

Learning time: 11h

Theory classes: 3h
Practical classes: 1h
Self study : 7h

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

Small satellite launchers

Learning time: 9h

Theory classes: 3h
Practical classes: 1h
Self study : 5h

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

Last update: 25-10-2018

19613 - ANP - Architecture of Nano and Picosatellites

Systems Engineering	Learning time: 7h Theory classes: 2h Practical classes: 1h Self study : 4h

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

Structure	Learning time: 11h Theory classes: 3h Practical classes: 1h Self study : 7h

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

Power Subsystem	Learning time: 11h Theory classes: 3h Practical classes: 1h Self study : 7h

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

Last update: 25-10-2018

19613 - ANP - Architecture of Nano and Picosatellites

Communications	Learning time: 11h Theory classes: 3h Practical classes: 1h Self study : 7h

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

Tracking, Telemetry, and Commands	Learning time: 6h 30m Theory classes: 1h 30m Practical classes: 0h 30m Self study : 4h 30m

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

Thermal control	Learning time: 11h Theory classes: 3h Practical classes: 1h Self study : 7h

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

Last update: 25-10-2018

19613 - ANP - Architecture of Nano and Picosatellites

Onboard computer	Learning time: 7h Theory classes: 2h Practical classes: 0h 30m Self study : 4h 30m

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

Attitude Determination and Control	Learning time: 11h Theory classes: 3h Practical classes: 1h Self study : 7h

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

Propulsion	Learning time: 11h Theory classes: 3h Practical classes: 1h Self study : 7h

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

Last update: 25-10-2018

19613 - ANP - Architecture of Nano and Picosatellites

Tests	Learning time: 6h Theory classes: 1h 30m Practical classes: 0h 30m Self study : 4h

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

Cost analysis	Learning time: 5h 30m Theory classes: 1h Practical classes: 0h 30m Self study : 4h

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

Legal issues	Learning time: 4h Theory classes: 1h Self study : 3h

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

Qualification system

Defined in the course webpage at the EETAC website.

Last update: 25-10-2018

19613 - ANP - Architecture of Nano and Picosatellites

Bibliography

Basic:

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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.

Helvajian, Henry. Microengineering aerospace systems. El Segundo, Calif.: Aerospace Press, cop. 1999. ISBN 1884989039.

Complementary:

Wertz, James Richard; Larson, Wiley J. Reducing space mission cost. Torrance, Calif. : Dordrecht ; Boston: Microcosm Press ; Kluwer Academic Publishers, cop. 1996. ISBN 0792340213.

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.