Course guide
300504 - IE - Introduction in Space

Last modified: 05/07/2024

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

Degree: BACHELOR'S DEGREE IN SATELLITE ENGINEERING (Syllabus 2024). (Compulsory subject).

Academic year: 2024 **ECTS Credits:** 6.0 **Languages:** English

LECTURER

Coordinating lecturer: Definit a la infoweb de l'assignatura

Others: Definit a la infoweb de l'assignatura

PRIOR SKILLS

None.

REQUIREMENTS

None.

TEACHING METHODOLOGY

The subject will be taught combining master classes (theoretical, problem and preliminary system design sessions) and laboratory and programming sessions. The theoretical classes will mainly follow the expository model, where teachers will introduce the necessary concepts to later apply them in the resolution of the problems of each topic or the preliminary design of an engineering system. The active participation of students during classes will be encouraged. Examples clearly oriented to the subject of the degree will be chosen with the aim of promoting student motivation. Likewise, specific software will be used, so that the proposed case studies can be simulated and visually represented.

Expert speakers in the space field will also be invited so that students have a first-hand introduction to the different current aspects of space exploration and use (including ethical, sustainability and international cooperation aspects).

The laboratory sessions will be aimed at students developing and applying the contents explained in class with a more active role. The laboratory sessions will be held in groups of 2/4 students. The type of practices will involve the use of satellite emulators, test and measurement instruments and simulation software. In some cases, students will be asked to generate small codes for numerical calculation.

LEARNING OBJECTIVES OF THE SUBJECT

At the end of the topic Introduction to Space, the student must be able to:
1. Perform basic calculations of circular and elliptical orbits.
2. Select a launcher based on the requirements and limitations of a space mission.
3. Describe the parts that make up an artificial satellite and their applications.
4. Analyse the effects of the space environment on satellites.
5. Describe the various applications of satellites in diverse fields (Earth observation, science, telecommunication, navigation).
6. Know and describe the general regulatory and economic framework of space missions.
7. Communicate clearly and effectively orally and in writing to justify scientific reasoning with qualitative and quantitative arguments.
8. Acquire knowledge independently, using the sources of information and the indicated guidelines, and identify learning deficiencies.

LEARNING RESULTS

At the end of the learning activities of the Space Engineering subject, the student will be able to:
Knowledge
K1. Identify the concepts related to space engineering and their application in satellites.
K2. Identify the regulatory, social, ethical, environmental, commercial, exploitation, and technical and economic feasibility limitations of a development in the field of space engineering.
Skills
S1. Perform measurements, calculations, evaluations, reports, and task planning, managing specifications, regulations, and mandatory standards.
S2. Solve problems with initiative, decision-making, and creativity, emphasizing the ethical and professional responsibility of space engineering.
Competences
C1. Perform tasks and projects individually or as part of a group, according to a set of initial requirements.
C2. Communicate orally and in writing with others about the results of learning and decision-making processes.

CONTENTS

1. History of space exploration.

Description:
1.1 The prehistory of space exploration.
1.2 The pioneers of astronautics.
1.3 The space race and the arrival on the Moon.
1.4 The era of space stations and small satellites.
1.5 The near future.

Related activities:
AV2: Mid-term exam (MQ).

Full-or-part-time: 5h
Theory classes: 2h
Self study : 3h

2. Our Place in the Cosmos.

Description:
2.1 Celestial coordinates.
2.2 Sidereal and universal time.
2.3 The motions of the Earth.
2.4 Our neighbourhood: the Solar System.
2.5 The sun.
2.6 The Cosmos: from the Big Bang to the present.

Related activities:
AV1: Use of the Stellarium software.
AV2: Midterm Exam (MQ).
AV7: Final Exam (FQ)

Full-or-part-time: 25h
Theory classes: 11h
Self study : 14h

3. Rockets and Launchers.

Description:
3.1 Conservation of linear momentum, Newton principles and Rockets.
3.2 Performance metrics.
3.3 Propulsion technologies: liquid and solid fuel rockets.
3.4 Launchers.
3.5 Space propulsion.

Related activities:
AV2: Midterm exam (MQ).
AV7: Final exam (FQ).

Full-or-part-time: 13h 30m
Theory classes: 6h
Self study : 7h 30m

4. Orbital Motion.

Description:
4.1 Kepler's laws.
4.2 Newton's law of gravitation.
4.3 Circular orbits. The two-body problem.
4.4 Classical orbital elements.
4.5 Lunar and interplanetary trajectories.

Related activities:
AV3: Orbital Mechanics. Use of STA or STK.
AV7: Final Exam (FQ).

Full-or-part-time: 22h 30m
Theory classes: 10h
Self study : 12h 30m

5. Space environment.

Description:
5.1 The gravitational field.
5.2 The high atmosphere.
5.3 The magnetosphere.
5.4 Ionized medium.
5.5 Meteoroids and space debris.

Related activities:
AV7: Final exam (FQ).

Full-or-part-time: 7h
Theory classes: 3h
Self study : 4h

6. Systems engineering.

Description:
6.1 The design of complex systems.
6.2 Requirements, drivers, tradeoffs...
6.3 Concurrent engineering.

Specific objectives:
AV7: Final exam (FQ).

Full-or-part-time: 7h
Theory classes: 3h
Self study : 4h

7. Satellite Subsystems

Description:
7.1 Structure
7.2 Attitude determination and control.
7.3 Thermal control.
7.4 Electric power
7.5 Communications
7.6 Tracking, telemetry and command.
7.7 On-board computer
7.8 Life support

Related activities:
AV5: Use of the General Mission Analysis Tool simulation software.
AV6: Helmholtz coils.
AV7: Final exam (FQ).

Full-or-part-time: 36h
Theory classes: 16h
Self study : 20h

8. The uses of space.

Description:
8.1 Earth observation.
8.2 Telecommunication.
8.3 Meteorology.
8.4 Global Navigation Satellite Systems.
8.5 Science in and from space.
8.6 Crewed missions.

Related activities:
AV4: Use of the Bilko software for Earth Observation.
AV7: Final exam (FQ).

Full-or-part-time: 25h
Theory classes: 11h
Self study : 14h

9. Space Law, Politics and Commerce.

Description:
9.1 The United Nation's space treaties.
9.2 The space nations.
9.3 The New Space: a paradigm shift.
9.4 Ethics, sustainability and international cooperation.

Related activities:
AV7: Final exam (FQ).

Full-or-part-time: 9h
Theory classes: 4h
Self study : 5h

ACTIVITIES

AV1. Use of the Stellarium software.

Description:
Students will work in teams of two in the computer laboratory to study the orbital trajectory of a satellite.

Specific objectives:
Encourage team work and Independent Learning. Check understanding of the subject 2. Develop analytical and technical written communication skills. Use of the third language.

Material:
Laboratory session guide and laboratory report template.

Delivery:
Student laboratory report.

Full-or-part-time: 6h
Self study: 4h
Laboratory classes: 2h

AV2. Midterm exam.

Description:
An individual exam that will include exercises and theoretical questions about the contents of the subject.

Specific objectives:
Check the students' competence in knowledge and the ability to reason and solve problems from the contents of Introduction to Space (themes 1, 2, 3 and 4).
Encourage the development of analytical and technical writing skills, justifying the answers to each question or problem.

Material:
Proposed assessment exercises, formulae list and table of integrals on paper, calculator.

Delivery:
Student written answers. The deliverable can be handed out in Catalan, Spanish or English.

Full-or-part-time: 12h
Self study: 10h
Theory classes: 2h

AV3. Orbital Mechanics with GMAT.

Description:
Students will work in teams of two in the computer laboratory to plot different types of orbits and orbit transfers. They will work through simple exercises using the General Mission Analysis Tool (GMAT).

Specific objectives:
Encourage team work and Independent Learning. Check your understanding of lesson 3. Introduce yourself to the use of software used in professional environments. Develop technical written communication skills. Use of the third language.

Material:
Laboratory session guide and laboratory report template.

Delivery:
Student laboratory report.

Full-or-part-time: 5h
Self study: 3h
Laboratory classes: 2h

AV4. Use of Bilko (ESA and UNESCO) for Earth Observation.

Description:
Students will work in teams of two in the computer laboratory to analyse satellite images of various terrestrial environments.

Specific objectives:
Encourage team work and Independent Learning. Apply fundamental Earth observation techniques to obtain information from satellite images. Develop technical written communication skills. Use of the third language.

Material:
Laboratory session guide and laboratory report template.

Delivery:
Student laboratory report.

Full-or-part-time: 8h
Self study: 6h
Laboratory classes: 2h

AV5. Mission Analysis using General Mission Analysis Tool (NASA).

Description:
Students will work in teams of four in the laboratory to simulate contacts with the ground station of a satellite in low Earth orbit.

Specific objectives:
Encourage team work and Independent Learning. Introduce concepts of mission analysis with examples taken from reality. Develop technical written communication skills. Use of the third language.

Material:
Laboratory session guide and laboratory report template.

Delivery:
Student laboratory report.

Full-or-part-time: 6h
Self study: 4h
Laboratory classes: 2h

AV6. Helmholtz coils.

Description:
Students will work in teams of four in the laboratory to operate and make measurements with Helmholtz coils.

Specific objectives:
Encourage team work and Independent Learning. Introduce satellite test methodologies. Develop skills to work with measurement and test equipment. Develop technical written communication skills. Use of the third language.

Material:
Laboratory session guide and laboratory report template.

Delivery:
Student laboratory report.

Full-or-part-time: 6h
Self study: 4h
Laboratory classes: 2h

AV7. Final exam.

Description:
An individual exam that will include exercises and theoretical questions about the contents of the subject.

Specific objectives:
Assess the students' competence in the knowledge and their ability to reason and solve problems and design systems of the contents of Introduction to Space.
Encourage the development of analytical and technical writing skills, justifying the answers to each question or problem.

Material:
Proposed assessment exercises, formulae list and table of integrals on paper, calculator.

Delivery:
Student written answers. The deliverable can be delivered in Catalan, Spanish or English.

Full-or-part-time: 22h
Self study: 20h
Theory classes: 2h

GRADING SYSTEM

The final grade will be obtained from:

1. Two exams, one in the middle of the semester and one at the end. In these exams, the content of the conferences given by external experts may be evaluated.
2. Laboratory sessions and reports.
3. Realization of a group design project.
4. Development of a written topic.

EXAMINATION RULES.

1. Any exam or submission not presented will be evaluated with a score of zero.
2. The evaluations of the exams will be individual.
3. Laboratory reports will be evaluated in groups.

BIBLIOGRAPHY

Basic:
- Damon, T.. Introduction to Space. 1. Krieger Publishing Company, 2011. ISBN 978-0894640681.
- Sellers, J., Astore, W., Giffen, R., Larson, W. J.. Understanding Space. 1. McGraw-Hill Education, 2007. ISBN 978-0077230302.

Complementary:
- Galadí-Enríquez, David; Gutiérrez Cabello, Jordi; Salvador Solé, Eduard; Peris, Vicent. De la Tierra al universo : astronomía general teórica y práctica . 2.ª edición. Tres Cantos : Akal, [2022]. ISBN 978-8446051459.
- Artola, R.. La Carrera espacial. 1. Alianza editorial, 2019. ISBN 978-8491815204.
- Shetterly, M. L.. Hidden Figures. 1. Harper, 2016. ISBN 978-0008201326.

RESOURCES

Other resources:
Students will have lecture notes for the subject.

Software:
1. Stellarium (https://stellarium.org/es/) />
2. General Mission Analysis Tool (https://software.nasa.gov/software/GSC-17177-1) />
3. Bilko (https://bilko.org/)