Astrodynamics

Second Semester – Spring

Objectives of the course:

To offer a view on artificial satellites dynamics and motion around the Earth and around liberation points. To provide knowledge on how to calculate interplanetary trajectory calculation. Artificial satellites control.

Description of the course:

1. Two-body problem reminder.
2. Orbit determination methods.
3. Gravitational and non-gravitational perturbations.
4. Liberation orbit.
5. Propulsion and reentrance notions.
6. Lunar and interplanetary missions.
7. Attitude maneuvers.
8. Formation flight.

Assessment:

1. Delivered Exercises
2. Two Small Projects (un pairs or groups of 3)
3. Final Exam

Number of credits:

5 ECTS – Second semester

Faculty in charge:

Josep J. Masdemont

Selected references:

1. R.B. Bate and D.D. Mueller and J.E. White. Fundamentals of Astrodynamics. Dover Publications. 1971.
2. R.H. Battin. An Introduction to the Mathematics and Methods of Astrodynamics. AIAA Education Series. 1987.
3. V. Chobotov V. (ed.). Orbital Mechanics. AIAA Education Series. 1991.
4. G. Gómez, C. Simó, A. Jorba and J. Masdemont. Dynamics and Mission Design near Libration Points. Volume 3: Advanced Methods for Collinear Points. World Sci. Publishing, Singapur, 2000.
5. G.A. Gurzadyan. Theory of Interplanetary Flights. Gordon and Breach Publishers. 1996.

Architecture of Nano and Picosatellites

Second Semester - Spring

Objectives of the course:

To analyze the low-weight satellites, giving special attention to the differences in front of the heavy satellites. To study scientific and business applications for low-weight satellites.

Description of the course:

1. Nano and Picosatellites introduction.
2. Available launchers.
3. Earth environment
4. Subsystems and useful payloads:
   1. Structure
   2. Power
   3. AOCS
   4. Computation
   5. Thermal control
   6. Communications
5. Ground Stations
6. Low-cost strategies
7. Program management and reliability
8. Social and politic facts

Number of credits:

5 ECTS – Second semester

Faculty in charge:

Jordi Gutiérrez i Cabello

Selected references:

1. Fleeter, R. The logic of microspace : [technology and management of minimum-cost missions]. El Segundo, Calif. : Microcosm Press ; Dordrecht, Netherlands : Kluwer Academic Publishers, 2000. ISBN 0792360281.
2. Helvajian, H. (ed.). Microengineering aerospace systems. El Segundo, CA : Aerospace Press ; Reston, VA : American Institute of Aeronautics and Astronautics, 1999. ISBN 1884989039.
3. Micci, M. M. ; Ketsdever, A. D. (ed.). Micropropulsion for small spacecraft. Reston, Va.: American Institute of Aeronautics and Astronautics, 2000. ISBN 1563474484.
4. Wertz, J. R. ; Larson, J. (ed.). Reducing space mission cost. Torrance, Calif. : Microcosm Press ; Dordrecht ; Boston : Kluwer Academic Publishers, 1996. ISBN 0792340213.
5. Fortescue, P. ; Stark, J. ; Swinerd, J. (ed.). Spacecraft systems engineering. 3a ed. New York : John Wiley, 2003. ISBN 0470851023

Aviation Weather

Second Semester - Spring

Objectives of the course:

Offer a deep vision of the environment where most of the aeronautical performances happen: the atmosphere. In special, to study thoroughly different atmospheric phenomenon that affects the flight: turbulence, icing, storms, CAT, and how this information is transmitted to the pilots.

Description of the course:

Atmosphere structure.
Atmospheric dynamics: convection, turbulence, wind.
Humidity, clouds, rainfall, storms.
Visibility.
Meteorological Information: on surface, in flight, satellites, significant maps, METAR, SIGMET.

Number of credits:

5 ECTS – Second semester

Faculty in charge:

David Pino González

Composite Materials for Aerospace Applications

Second Semester - Spring

Objectives of the course:

To present and study composite materials, especially those constituted by a polymer matrix and fibrous reinforcements, which are used at aerospace manufacturing, including new generation nanocomposites materials. To study mechanical and fracture behavior of these materials, depending on their own matrix and reinforcement constitution, reinforcement geometry and processing technique. Description and analysis of the main transformation process, as well as the most useful testing and quality control methods.

Description of the course:

1. Composite materials for aerospace applications
2. Composite matrixes
3. Composite reinforcements
4. Composite structures
5. Processing techniques
6. Testing methods
7. Quality control

Assessment:

Project based on bibliographic research.

Number of credits:

5 ECTS – Second semester

Faculty:

José Ignacio Velasco, Edgar A. Franco

Selected references:

- Chawla,K.K., Composite Materials: Science and Engineering, Wiley, 2001.
- Hull, D. and T.W. Clyne, An Introduction to Composites Materials, Cambridge University Press, 1996.
- Aerospace Composites. A Design and Manufacturing Guide. A Supplement to Gardner Publications. Composites Magazine, 2008.
- http://www.reinforcedplastics.com

Computational Fluid Dinamics in Aerospace Engineering

Second Semester - Spring

Objectives of the course:

- Introduction to the need and limitations of CFD as a research tool.
- Understanding of the fluid dynamics governing equations.
- Provide an insight into some numerical techniques.
- Introduction to a CFD commercial tool (Ansys/Fluent).

Description of the course:

1. Introduction to CFD
2. Fluid dynamics governing equations
3. Classification of partial differential equations
4. Discretization:
    1. Finite differences
    2. Finite volume
5. Numerical analysis
6. Some simple CFD techniques
7. Turbulence

Assessment:

Papers presentations and discussion.
Exercises.
CFD project.

Number of credits:

5 ECTS – Second semester

Faculty:

Ricard González Cinca

Selected references:

1. J.D. Anderson, Computational Fluid Dynamics, McGraw-Hill, 1995.
2. J.D. Anderson, Fundamentals of Aerodynamics, McGraw-Hill, 2001.
3. K.A. Hoffman, S.T. Chiang, Computational Fluid Dynamics for Engineers, Vols. 1,2, Engineering Education System, 1993.
4. H. K. Versteeg and W. Malalasekera, An introduction to Computational Fluid Dynamics, Pearson Prentice Hall, 1995.
5. W.H. Press, S.A. Teukolsky, W.T. Vetterling, B.P. Flanner, Numerical Recipes in C/Fortran, Cambridge University Press, 1994.

Digital Avionic Systems

Second Semester - Spring

Objectives of the course:

The course will provide the student with the technology knowledge to build (develop, integrate and test) a digital avionic system for an aircraft, following safety engineering processes. Emphasis is given on research, innovation and evaluation of novel avionics functions.

Description of the course:

- There are three parts in the course: teacher lectures (25 hours), students project essay (80-100 hours) and practical hands-on seminar (20 hours). The typical schedule of the course follows the three parts sequentially on the calendar: first 5-6 weeks for lectures, next 10-12 weeks for project and last 2 weeks for seminar.
- The teacher lectures give the theoretical background. The lessons are:
    1. Definition and history of Digital Avionics Systems
    2. Functions: Communication, Navigation, Maintenance and Displays
    3. Avionics Examples: MD-11, B-777, A-320
    4. Avionics Architectures: Centralized, Federated, Distributed
    5. Avionics Buses: Computers buses, ARINC 429
    6. Avionics APEX: RTOS, ARINC 653
    7. Avionics Software: Certification, EIA-632, DO-297, DO-178
- The students essay consists in a first practice for introducing them to the Flight Gear simulator, a second practice to create a flight plan in the ICARUS Simulation Integrated Scenario (ISIS), and a final part organized as a project to propose, implement and evaluate a new avionics system on top of ISIS. The project results will be written as a research paper for the Digital Avionics Systems Conference or similar topic journals.
- At the end the semester an invited professor teaches a 2 weeks seminar on FPGAs (Field Programmable Gateway Arrays).

Assessment:

Grades are obtained from the three part of the course with the following weight:

1. 20% final exam
2. 60% practices: 20% practices1&2 + 20% project implementation + 20% paper writing
3. 20% seminar assistance

Number of credits:

5 ECTS – Second semester

Faculty:

Cristina Barrado (coordinator), Enric Pastor, P. Borensztejn

Selected references:

1. IEEE Digital Avionics Systems Conferences (http://www.dasconline.org/. Access available from the digital library IEEE Explore)
2. Digital Avionics Systems Handbook: Avionics Elements, Software and Functions. Cary R. Spitzer. CRC Press. 2nd Ed.
3. Digital Avionics Systems Handbook: Avionics Development and Implementation. Cary R. Spitzer. CRC Press. 2nd Ed.
4. ARINC 429/629,653 and 661 tutorials. ARINC.
5. POSIX and ARINC for
   Safety-Critical Applications
   Linux Works DOC-0620-00
6. RTCA DO-178 - RTCA, Incorporated.

Integrated Electronic Systems for Aerospace Applications

Second Semester - Spring

Number of credits:

5 ECTS – Second semester

Faculty in charge:

Carles Ferrer, Francesc Serra, Joan Oliver

Life Support Systems in Space

Second Semester - Spring

Objectives of the course:

To know the different technologies in development for Life Support in Space and how they are tested. To know what are the main elements to consider when designing a Life Support System for a given mission scenario.

Description of the course:

The Course is divided in the following parts:

a) Lecture blocks:
   1. Introduction to Life Support Systems. Needs. Mission scenarios. Test facilities.
   2. Physico-chemical LS technologies
   3. Biological LS technologies, including a basis of Biotechnology
   4. Methodologies for trade-off technologies. ESM. Examples.

b) Site visit: MELiSSA Pilot Plant (UAB)

c) Study cases (activity in groups of 3-4 students): analysis, based on literature papers, on a Life Support System facility/test-bed. Public presentation of study cases by students.

Number of credits:

5 ECTS – Second semester

Faculty in charge:

Francesc Gòdia

Selected references:

NASA Design Reference Mission. (DRM).

Czupalla, M. et al., Analysis of a spacecraft life support system for a Mars mission. Acta Astronautica 55 (2004) 537-547.

Modern Control Systems

Second Semester - Spring

Objectives of the course:

This course provides a background on standard control methods in engineering systems, with special emphasis on applications. The course will also develop practical skills to implement the methods using MATLAB/SIMULINK.

Description of the course:

The course is organized as 11 sessions of 4 h each. The following list summarizes the contents:

1. Architecture of control systems:
   - Open and closed loop architectures. Control variables. Feedback.
2. Dynamic models and time response:
   - Modeling mechanical, electrical, electromechanical and fluid systems.
   - Analysis of the transient and stationary response. Laplace transform, z-transform. Transfer function.
3. Standard controller design methods:
   - The root-locus method. Design by frequency techniques. Bode and Nyquist plots.
4. State-space methods:
   - State-Space models, design of state-feedback controllers. Controllability.
5. Estimator design:
   - Estimation of control state variables. Observability. Kalman filters.
6. Optimal and robust control:
   - Quadratic cost functions. Linear-quadratic regulator (LQR). Linear-quadratic Gaussian control (LQG). Robust control. H-infinity methods.
7. Control of nonlinear systems:
   - Introduction to nonlinear dynamical systems. Typical nonlinearities. Linearization. The describing function method.

Assessment:

- Assignments 50%
- Final exam 50%

Number of credits:

5 ECTS – Second semester

Faculty:

R. Benítez

Selected references:

1. K. Ogata, Modern Control Engineering (Prentice Hall, 5th Ed, 2009)
2. N. S. Nise, Control Systems Engineering (Addison-Wesley, 4th Ed, 2003)
3. G. F. Franklin, J. D. Powell and A. Emani-Naeini, Feedback Control of Dynamic Systems (Pearson, 6th Ed, 2010).

Nanotechnologies for Space Applications

Second Semester - Spring

Objectives of the course:

To know the differences about the macro and nanoscale behavior. To identify the special features of the nanoscale process and mechanisms, in order to design sensors, materials and space life support systems.

Description of the course:

1. Nanotechnology introduction
2. Molecular level matter behavior
3. Nanotechnology role in space exploration
4. Nanotechnologies space applications I: Sensors
5. Nanotechnologies space applications II: Materials
6. Nanotechnologies space applications III: Life support systems

Number of credits:

5 ECTS – Second semester

Faculty in charge:

Ignasi Casanova

Radionavigation

Second Semester - Spring

Objectives of the course:

Theoretical-practical study of the different navigation algorithms for Global Navigation Satellite System System (GNSS) to provide the student with a rigorous knowledge about the GNSS data processing. Is expected to promote the instrumental uses of concepts and techniques in GNSS satellite navigation.

Description of the course:

- GNSS Data Processing: Theory
  - Lecture 0: Introduction
  - Lecture 1: GNSS measurements and their combinations
  - Lecture 2: Satellite orbits and clocks computation accuracy
  - Lecture 3: Position estimation with pseudoranges
  - Lecture 4: Introduction to DGNSS
  - Lecture 5: Precise positioning with carrier phase (PPP)
  - Lecture 6: Differential positioning with code pseudoranges
  - Lecture 7: Carrier based differential positioning. Ambiguity resolution techniques
- GNSS Data Processing: Laboratory Exercises
  - Tutorial 0: UNIX enviroment, tools and skills. GNSS standard file formats
  - Tutorial 1: GNSS data processing laboratory exercises
  - Tutorial 2: Measurement analysis and error budget
  - Tutorial 3: Differential positioning with code measurements
  - Tutorial 4: Differential positioning and carrier ambiguity fixing
  - Tutorial 5: Analysis of propagation effects from GNSS observables based on laboratory exercises

Number of credits:

5 ECTS – Second semester

Faculty in charge:

Jaume Sanz Subirana, José Miguel Juan Zornoza

Selected references:

- Slides
  - GNSS Data Processing: Theory Slides (Full compendium)
  - GNSS Data Processing: Laboratory Exercises (Full compendium)

- Books
  - J. Sanz Subirana, J.M. Juan Zornoza and M. Hernández-Pajares, GNSS Data Processing, Volume 1: Fundamentals and Algorithms (ESA TM-23/1, May 2013)
  - J. Sanz Subirana, J.M. Juan Zornoza and M. Hernández-Pajares , GNSS Data Processing, Volume 2: Laboratory exercises (ESA TM-23/2, May 2013)

- Other books:
  - M. Hernández-Pajares, J.M. Juan Zornoza and J. Sanz, GPS Practical Book (GPS Data processing based on laboratory exercises) (in Spanish and English) , 2008.
  - Pratap Misra, Per Enge. Global Positioning System. Signals, Measurements, and Performance. Ganga-Jamuna Press, 2004.
  - B. Hofmann-Wellenhof et al. GPS, Theory and Practice. Springer-Verlag. Wien, New York, 1994.

Satellite Communication Principles

Second Semester - Spring

Objectives of the course:

This course aims at providing students with a solid knowledge of the fundamentals of the design techniques used in satellite communication.
Basic contents of the course are: description of a space radio link and its power balance, satellite and ground station equipment, architecture and development of modern satellite networks, multiple access and packet radio techniques, internet services via satellite and VSAT systems.

Description of the course:

I. Fundamentals of satellite communication
II. Link budget design
III. Transponder and Ground Station Equipments
IV. Coding and Modulations
V. Multiple access systems and Packet Transmission
VI. Internet protocol and satellite communications
VII. VSAT data networks

Assessment:

Satellite Communication Networks Project
The project will be a case study of some aspect related with satellite communication deployment (a program to represent orbits and coverage, a program to automatically design the link budget, specific coding and ARQ analysis, etc.). The project should be selected at the first week of class, so the student could start since the beginning of the course.
The project will end with the elaboration of a technical report and a public presentation in an internal workshop.

Number of credits:

5 ECTS – Second semester

Faculty:

Joan Olmos (coordinator), Silvia Ruiz.

Selected references:

1. Anil Kumar Maini, Varsha Agrawal. Satellite Technology: Principles and Applications. Wiley 2007.
2. G. Maral and M. Bousquet. Satellite communications systems. 5th ed. Wiley, 2009.
3. B. Elbert. The Satellite Communication Applications Handbook, Second Edition, Artech House, 2004.
4. Giovanni E. Corazza (Editor). Digital Satellite Communications. Springer 2007.
5. G. Maral. VSAT Networks. Wiley, 1995.
6. B. Pattan. Satellite-Based global cellular communications. McGraw-Hill, 1998.

Science in Microgravity

Second Semester - Spring

Objectives of the course:

1. To offer a view on the available microgravity platforms and the ways to access them.
2. To provide a broad introduction to research topics in microgravity conditions.
3. To provide the necessary tools to define and develope a research project to carry out in microgravity environment.

Description of the course:

The course is structured as follows:
1. Introduction to the course.
2. Space research.
3. Fundamental concepts, mathematical models and scaling analysis for the microgravity environment.
4. Modelling of two-phase flows.
5. Project definition and development.
6. Project presentation.

Number of credits:

5 ECTS – Second semester

Faculty in charge:

Ricard González Cinca.

Selected references:

1. M. Lappa, Fluids, Materials & Microgravity, Elsevier, 2004.
2. K. Gabriel, Microgravity two-phase flow and heat transfer, Space Technology Library, 2007.
3. Research papers.
4. http://www.esa.int/education
5. http://www.nasa.gov/multimedia/nasatv
6. http://microgravityuniversity.jsc.nasa.gov

Test and Instrumentation Systems in Aerospace Applications

Second Semester - Spring

Objectives of the course:

1. To study measure problems solution for science and airspace technology for consolidate measure system concept. Get depth in measure algorithms formulation in order to guarantee its quality.
2. To give the design and implementation knowledge for automatic measure systems.

Description of the course:

There are two parts: The application one and the basis one.

- In the basis part there are those units:
  - Advanced sensors systems.
  - Data obtaining systems.
  - Measures automation
  - Measuring methods and unknown measures analysis.
- The application part will be a project development based on the knowledge acquired in the basis part.

Number of credits:

5 ECTS – Second semester

Faculty in charge:

J. Oscar Casas Piedrafita, Ramon Pallàs Areny

Unmanned Aerial Vehicles

Second Semester - Spring

Objectives of the course:

To offer a global vision of UAV: history and current models. To provide knowledge to be able to design a complete UAV system: onboard segment and ground segment. To offer a view on UAV civil applications and to create them.

Description of the course:

1. UAV history.
2. Applications.
3. Current models.
4. UAV parts overview: planes and helicopters.
5. Flight Control System.
6. Communications.
7. Payload.
8. Control.
9. Ground-based station.
10. Experiences.

Number of credits:

5 ECTS – Second semester

Faculty in charge:

Pablo Royo (Coordinador), Enric Pastor