Last update: 18-10-2018

19386 - A - Astrodynamics

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

Teaching unit: 749 - MAT - Department of Mathematics

Academic year: 2018

Degree: MASTER'S DEGREE IN AEROSPACE SCIENCE AND TECHNOLOGY (Syllabus 2015). (Teaching unit Optional)
MASTER'S DEGREE IN AEROSPACE SCIENCE AND TECHNOLOGY (Syllabus 2009). (Teaching unit Optional)
DOCTORAL DEGREE IN AEROSPACE SCIENCE AND TECHNOLOGY (Syllabus 2007). (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

Strong basis in calculus and linear algebra. Some knowledge on ordinary differential equations, mechanics and numerical computations is also advised.

Degree competences to which the subject contributes

Basic:

CB6. (ENG) CB6 - Poseer y comprender conocimientos que aporten una base u oportunidad de ser originales en el desarrollo y/o aplicación de ideas, a menudo en un contexto de investigación.
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.
CB9. (ENG) CB9 - Que los estudiantes sepan comunicar sus conclusiones y los conocimientos y razones últimas que las sustentan a públicos especializados y no especializados de un modo claro y sin ambigüedades.
CB10. (ENG) CB10 - Que los estudiantes posean las habilidades de aprendizaje que les permitan continuar estudiando de un modo que habrá de ser en gran medida autodirigido o autónomo.

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.
CE6 MAST. (ENG) CE6: Realizar, presentar y defender ante un tribunal universitario un ejercicio original realizado individualmente, consistente en un estudio de investigación en el campo de la Ingeniería Aeroespacial, en el que se sinteticen las competencias adquiridas en las enseñanzas, adoptando los avances y novedades en este campo y aportando ideas novedosas.

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.
CG3 MAST. (ENG) CG3: Identificar y gestionar, de forma consistente, los diferentes tipos de vehículos aeroespaciales y los aspectos tecnológicos, de diseño e implementación de cargas útiles para misiones científicas.
CG4 MAST. (ENG) CG4: Participar en un proyecto de I+D+i del ámbito aeroespacial aportando una visión y

conocimientos novedosos asociados con las técnicas de uso más puntero en el campo.

Transversal:

CT1b. ENTREPRENEURSHIP AND INNOVATION: Being aware of and understanding the mechanisms on which scientific research is based, as well as the mechanisms and instruments for transferring results among socio-economic agents involved in research, development and innovation processes.
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.
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.
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.

Teaching methodology

Master classes will be eventually supported by slides but most details and problem examples, when possible, will be addressed on the blackboard.
Students should work in both autonomous and cooperative way when solving exercises and developing projects. Many cases, examples and problems requiring a big amount a computational basis will be solved using Matlab/Octave codes. Students will be required to use and/or to develop new scripts and functions during the class, or during the exam, using their own laptops.

Learning objectives of the subject

Having completed the subject in a satisfactory way, the student should be able to:
- Understand the main concepts associated with astrodynamics and orbital mission design.
- Provide qualitative and quantitative results for many kinds of problems related with orbit determination, orbital transfers,
  orbit perturbations,... in practical applications.
- Use some analytical techniques (series expansions, averaging properties, ...) for the analysis of problems related with celestial mechanics.
- Model dynamical systems in terms of vectorfieds, implement them in a computational form and numerically propagate trajectories accounting for accurate results.
- Compute orbit structures and dynamic building blocks in general dynamical systems.

Study load

Total learning time: 125h	Hours large group:	45h	36.00%
	Hours medium group:	0h	0.00%
	Hours small group:	0h	0.00%
	Guided activities:	0h	0.00%
	Self study:	80h	64.00%

19386 - A - Astrodynamics

Content

Introduction, General Concepts and Historical Perspective	Learning time: 7h Theory classes: 4h Self study : 3h

Description:
- Orbits about the Earth. General notions
- Kepler's and Newtons laws
- Basic models of celestial mechanics
- Basic problems in astrodynamics
- High and low energy transfers english

Related activities:
AFP1: Exposition of theoretical contents through lectures.
AFP5: Discussion in the classroom of problems or articles, made by the students and moderated by the teacher

AFN2: Realization of exercises and theoretical or practical works outside the classroom, individually or in a group

Classical Models of Orbital Mechanics	Learning time: 18h Theory classes: 6h Self study : 12h

Description:
- The N-body problem and the classical integrals
- The 2-Body Problem and the central force field problem
    - Integrals of energy and angular momentum
    - Equation of the trajectory
    - Conic sections and the geometry of conics
    - Patched conics and notions of interplanetary mission design

Related activities:
AFP1: Exposition of theoretical contents through lectures.
AFP3: Problem solving, with student participation.
AFP5: Discussion in the classroom of problems or articles, made by the students and moderated by the teacher
AFP6: Elaboration of cooperative works

AFN2: Realization of exercises and theoretical or practical works outside the classroom, individually or in a group
AFN3: Realization of projects proposed by teachers outside the classroom, individually or in groups.

Orbital Elements and the Measure of Time	Learning time: 21h Theory classes: 6h Self study : 15h

Description:
- Reference systems
- From Cartesian state to orbital elements and vice-versa
- The Two Line Elements
- The case of the orbit of the Earth about the Sun
- The celestial sphere. Notions of Spherical Astronomy and Spherical Trigonometry.
- The measure of time. Historical problems.
- Current time standards

Related activities:
AFP1: Exposition of theoretical contents through lectures.
AFP3: Problem solving, with student participation.
AFP5: Discussion in the classroom of problems or articles, made by the students and moderated by the teacher
AFP6: Elaboration of cooperative works

AFN2: Realization of exercises and theoretical or practical works outside the classroom, individually or in a group
AFN3: Realization of projects proposed by teachers outside the classroom, individually or in groups.

Kepler's Equation and Orbit Determination	Learning time: 14h Theory classes: 4h Self study : 10h

Description:
- Position and velocity as a function of time
- Changes between coordinate frames. Coriolis theorem.
- Kepler's equation
- Basic methods of orbit determination

Related activities:
AFP1: Exposition of theoretical contents through lectures.
AFP3: Problem solving, with student participation.
AFP5: Discussion in the classroom of problems or articles, made by the students and moderated by the teacher
AFP6: Elaboration of cooperative works

AFN2: Realization of exercises and theoretical or practical works outside the classroom, individually or in a group
AFN3: Realization of projects proposed by teachers outside the classroom, individually or in groups.

Orbital Maneuvers and Basic Transfers	Learning time: 16h Theory classes: 6h Self study : 10h

Description:
- Station coordinates and basic geodesy concepts
- Basic orbital transfers and orbit adjustments

Related activities:
AFP1: Exposition of theoretical contents through lectures.
AFP3: Problem solving, with student participation.
AFP5: Discussion in the classroom of problems or articles, made by the students and moderated by the teacher
AFP6: Elaboration of cooperative works

AFN2: Realization of exercises and theoretical or practical works outside the classroom, individually or in a group
AFN3: Realization of projects proposed by teachers outside the classroom, individually or in groups.

Gravitational and Non-Gravitational Perturbations	Learning time: 14h Theory classes: 6h Self study : 8h

Description:
- Orbital perturbations. Models
- Gauss and Lagrange palnetary equations
- Analysis of the J2 perturbation. Consequences and Applications.

Related activities:
AFP1: Exposition of theoretical contents through lectures.
AFP3: Problem solving, with student participation.
AFP5: Discussion in the classroom of problems or articles, made by the students and moderated by the teacher
AFP6: Elaboration of cooperative works

AFN2: Realization of exercises and theoretical or practical works outside the classroom, individually or in a group
AFN3: Realization of projects proposed by teachers outside the classroom, individually or in groups.

Dynamical Systems and Vectorfields	Learning time: 16h Theory classes: 6h Self study : 10h

Description:
- The concept of a Dynamical System
- Trajectories in a vectorfield
- The initial value problem and orbit propagation
- Numerical computations

Related activities:
AFP1: Exposition of theoretical contents through lectures.
AFP3: Problem solving, with student participation.
AFP5: Discussion in the classroom of problems or articles, made by the students and moderated by the teacher
AFP6: Elaboration of cooperative works

AFN2: Realization of exercises and theoretical or practical works outside the classroom, individually or in a group
AFN3: Realization of projects proposed by teachers outside the classroom, individually or in groups.

The Restricted Three Body Problem and Libration Point Orbits	Learning time: 19h Theory classes: 7h Self study : 12h

Description:
- Equations of motion
- Zero velocity curves
- Libration Points and their local analysis
- Libration Point orbits and Low energy transfers
- Numerical Computations

Related activities:
AFP1: Exposition of theoretical contents through lectures.
AFP3: Problem solving, with student participation.
AFP5: Discussion in the classroom of problems or articles, made by the students and moderated by the teacher
AFP6: Elaboration of cooperative works

AFN2: Realization of exercises and theoretical or practical works outside the classroom, individually or in a group
AFN3: Realization of projects proposed by teachers outside the classroom, individually or in groups.

Qualification system

Defined in the course webpage at the EETAC website

19386 - A - Astrodynamics

Bibliography

Basic:

Bate, Roger R; Mueller, Donald D; White, Jerry E. Fundamentals of astrodynamics. New York: Dover, cop. 1971. ISBN 9780486600611.

Battin, Richard H. An Introduction to the mathematics and methods of astrodynamics. Rev. ed. Virginia: American Institute of Aeronautics and Astronautics, 1999. ISBN 1563473429.

Gómez, G. Dynamics and mission design near libration points. Singapore [etc.]: World Scientific, 2001. ISBN 9810242859.

Vallado, David A; McClain, Wayne D. Fundamentals of astrodynamics and applications. 4a ed. Hawthorne: Microcosm Press, cop. 2013. ISBN 9781881883180.

Complementary:

Gurzadian, G. A. Theory of interplanetary flights. Australia [et al.]: Gordon and Breach, 1996. ISBN 2884490744.

Escobal, Pedro Ramon. Methods of orbit determination. Reprint with corrections. Malabar, FL: Krieger Pub. Co, 1976. ISBN 0882753193.

Sidi, M. J. Spacecraft dynamics and control : a practical engineering approach. Cambridge: Cambridge University press, 1997. ISBN 0521550726.

de Iaco Veris, Alessandro. Practical astrodynamics. Springer, 2018. ISBN 9783319622194.