Course guide
300078 - UA - Unmanned Aircraft

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Unit in charge: Castelldefels School of Telecommunications and Aerospace Engineering
Teaching unit: 710 - EEL - Department of Electronic Engineering.
739 - TSC - Department of Signal Theory and Communications.

Degree: MASTER'S DEGREE IN APPLICATIONS AND TECHNOLOGIES FOR UNMANNED AIRCRAFT SYSTEMS (DRONES) (Syllabus 2017). (Compulsory subject).

Academic year: 2020 **ECTS Credits:** 4.5 **Languages:** English

LECTURER

Coordinating lecturer: Defined in the infoweb of the course

Others: Defined in the infoweb of the course

PRIOR SKILLS

DC and AC circuit analysis, linear system theory, analysis and design of basic analog, digital and mixed-signal electronic circuits using passive and active electronic components. Basic concepts of communications sytems. Mathematicals basic skills.

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CE1 DRONS. (ENG) CE1 DRONS Analizar los requisitos de la misión, seleccionar la plataforma dron más adecuada de acuerdo a los requisitos (tipo de aeronave y sistemas energéticos, de propulsión, de posicionamiento, de navegación, de guiado, de telecomunicación, de seguridad y de emergencia) y realizar la verificación del sistema.

Generical:
CG1 DRONS. (ENG) CG1 DRONS Proyectar e implantar soluciones viables y rentables utilizando sistemas basados en aeronaves no tripuladas (drones) en entornos nuevos o poco conocidos dentro de contextos más amplios y multidisciplinares

Transversal:
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:
CB6 DRONS. (ENG) CB6 DRONS 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
CB9 DRONS. (ENG) CB9 DRONS 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 DRONS. (ENG) CB10 DRONS 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.

TEACHING METHODOLOGY

The professors of this matter recognise that the learning and teaching strategy should reflect the different requirements of the students. In order to achieve this professors have agreed the following strategy:
1. To ensure that the teaching methods adopted for classroom and related activity are planned to ensure that tutors use a range of examples, reflecting the diversity of experiences when explaining the application of theory to practise.
2. To ensure that group discussions, case study / problem solving activity relate to and reflect the different aspects of practice represented within the classroom.
3. Where guest lecturers are used, they will be briefed by the module tutor to ensure that they are aware of the student profile and that the proposed presentation accommodates this.
4. Students will be supported by tutorial discussions between the tutor and student to ensure that the proposed learning reflects the practice needs of the student.
5. To ensure that the assessment strategy and methods of assessment are sufficiently flexible to enable students to apply and demonstrate their learning in a context which is relevant to them.
The learning and teaching methods adopted reflect the Drone Master’s degree characteristics descriptors in the following ways:
a) Lectures are used to impart key information and show case new ways of working which will enable students to develop a sound understanding of the principles of their field of study as well as identifying new ways of working.
b) Case studies, role plays and group working will be used to facilitate application of the principles more widely. They will also be used to prompt discussion and Practise problem solving skills. This will also allow students to evaluate the appropriateness of different approaches to solving problems.
c) Assessments are used to facilitate learning as well as providing an indication of student achievement.

LEARNING OBJECTIVES OF THE SUBJECT

The central element of the drone-based system is the aircraft itself. In this subject the several existing aircraft types will be studied, including but not limited to their characteristics, feeding and propulsion systems, actuators, autopilots, sensors and communication systems, etc...The subject gives the student the adequate criteria for the accurate selection of the aircraft and its components based on the requested mission. At the end of the course the student should be able to:

a) Understand the global vision, aircraft providers and fabricants.
b) Understand the Unmaned aircraft definition and its components.
c) Describe and design Propulsion and energy systems in unmaned aircrafts.
d) Analyse and design sensors systems and actuators
e) Analyse and design stability, navegation and guide systems.
f) Analyse and design communication systems in unmaned aircrafts.

STUDY LOAD

Type	Hours	Percentage
Hours small group	27,0	24.00
Self study	85,5	76.00

Total learning time: 112.5 h

CONTENTS

1. Introduction to UAVs

Description:
The first portion of the session reviews the history of UAV systems from the earliest and crudest "flying objects" through the events of the last decade, which has been a momentous period for UAV systems. The second portion of the session describes the subsystems that comprise a complete UAV system configuration to provide a framework for the subsequent treatment of the various individual technologies that contribute to a complete UAS. The air vehicle itself is a complicated system including structures, aerodynamic elements (wings and control surfaces), propulsion systems, and control systems. The complete system includes, in addition, sensors and other payloads, communication packages, and launch and recovery subsystems.

1.1 UAV definition.
1.2 Terminologies of UAV
1.3 History of UAV
1.4 Classifications of UAV
1.5 UAV components: Controller and computing. Power supply. Sensors systems. Actuators. Flight controls and Communications
1.6 UAV applications

Related activities:
Lectures, homework: questionnaires and exercises.

Full-or-part-time: 9h 20m
Laboratory classes: 3h
Self study : 6h 20m

2. Propulsion and energy systems

Description:
Two aspects of propulsion are addressed in this topic The first is the aerodynamics of generating thrust or what is called "powered lift," which is lift that is directly generated by a rotor or fan and is very similar to upward thrust. The second aspect of propulsion is the source of the power to produce the thrust or lift, which is the engine or motor that moves a propeller or rotor or fan. Finally, the energy sources and the power conditioining circuits are presented.

2.1 Overview
2.2 Thrust Generation
2.3 Powered Lift
2.4 Sources of Power. Motor and propeller models. Electronic controls and drivers
2.5 Power supply systems. Batteries. Linear and switching regulators. Efficiency.

Specific objectives:

Related activities:
Lectures of complementary material about Motors and switching regulators
Homework: problems about motor models and control (8 %)
Practical homework about motor control or sensor acquisition (8 %)

Full-or-part-time: 17h 50m
Laboratory classes: 5h
Self study : 12h 50m

3. Sensor, inertial and navigation systems

Description:
In this topic the electronic models of the sensor systems that can be used in a drone will be presented, as well as their basic conditioning. Emphasis will be placed on inertial systems and navigation systems, their models and errors, which are fundamental to the design of drones. Possible causes of interference, their models and reduction from the point of view of optimal drone design will also be presented.

3.1 Sensor systems. Types and electronic conditioning.
3.2 Introduction to stabilisation, guidance and navigation systems
3.3 Inertial systems. Uncertainties factors. Interferences and electromagnetic compatibility. Calibrations methods.
3.4 Satellite navigation systems: GPS, EGNOS, GBAS

Specific objectives:

Related activities:
Lectures of complementary material about inertial systems
Homework: problems about sensor acquition (8%) and navigation and inertial sensors (8 %)
Practical homework about motor control or sensor acquisition (8 %)

Full-or-part-time: 32h
Laboratory classes: 9h
Self study : 23h

4. Communication systems. Data link

Description:
This topic provides a general description of the functions and attributes of the data-link subsystem of a UAS and describes how the attributes of the data link interact with the mission and design of the UAV. The data link provides a communications link between the UAV and its ground station, and is a critical part of the complete UAV. It is very important for the designers to realize that the characteristics of the data link must be taken into account in the design of the total system, with numerous tradeoffs between the mission, control, and design ofthe UAV and the design of the data link.

4.1 Overview of UAV communication systems. Features and design
4.2 Data link functions and attributes
4.3 Data link margin. Transmitter Power. Antenna Gain. Processing Gain. Losses. Obstruction of the Propagation Path
4.4 Data-Link Signal-to-Noise Budget
4.5 UAV telemetry and communication examples

Related activities:
Homework: problems and theoretical quaestions about communication systems in drones (8 %)

Full-or-part-time: 20h 10m
Laboratory classes: 6h
Self study : 14h 10m

5. UAV simulation and control

Description:
The matter of this topic is approximate the performance of any DC motor or propeller from empirical data mathematically. Understand and harness the Physics of a Drone. Convert physical motion (throttle, roll, pitch, yaw) to voltage signals. Derive, understand and model the rotational dynamics of a drone (pitch, roll and yaw motion). Implement mathematical functions in Matlab and Simulink. Create and test an engineering model in Simulink. Design, tune and implement automated PID algorithms (altitude control and rotational dynamics).

5.1 Physics model of a drone. Rotational dynamics of a drone
5.2 Drone simulation. Matlab and simulink
5.3 Drone control. Design and tune PID algorthims

Related activities:
Theoretical quaestions ans simulations with matlab about control systems in drons. As it is the last topic of the course, the practical work is optionally extended with the realization of the research project in this topic

Full-or-part-time: 20h 40m
Laboratory classes: 4h
Self study : 16h 40m

6. Research project

Description:
Application and extension of the knowledge acquired on an assigned topic from a list of proposals made by teachers. Each proposal clearly defines the objective of the project and the expected results. The results of the research project will be documented in the form of a research paper. The main topics dealt with in relation to this subject will be: models, simulation and control of drones, since they are topics that require a timeframe in their development that the hours adjusted to the subject do not allow to cover in depth.

Related activities:
Preliminary version of the research paper
Evaluation of the preliminary version of at least two classmates
Final version of the research paper. (20%)

Full-or-part-time: 12h 30m
Self study : 12h 30m

GRADING SYSTEM

Assessment:
a) Unseen final written exam: 40 %
b) Problem-solving exercises, design exercises: 40 %
c) Research project: 20 %

EXAMINATION RULES.

The final exam will be three hours long and will consist of problems and theoretical issues. Students have a second opportunity (in May) to take the final exam

Examination Policies and Best Practices:
a) Check student IDs when they enter the classroom and check them off of a class list or ask students to sign the list as the ID card is checked.
b) Make sure to give each student only one exam form and that at the end of the exam only one is submitted by each student.
c)Create multiple forms of one exam, if it is necessary (Extraordinary non-presential examinations due to the Covid-19 pandemic). Use different questions or the same questions scrambled. Warn students that the exams differ and that misconduct will be apparent when the exam is graded.
d) Tell students about the Code of Academic Honesty and remind them about the importance of academic integrity and the consequences of misconduct.

BIBLIOGRAPHY

Basic:
- Sadraey, M. H. . Design of Unmanned Aerial Systems. 1st. USA: John Wiley & Sons Ltd, 2020. ISBN 978-1-119-50870-0.
- Fahlstrom, Paul Gerin; Gleason, Thomas J. Introduction to UAV systems [Recurs electrònic] [on line]. 4th ed. Chichester: Wiley, 2012 [Consultation: 06/11/2020]. Available on: https://onlinelibrary.wiley.com/doi/book/10.1002/9781118396780. ISBN 9781118396780.
- Valavanis, Kimon P. Advances in Unmanned Aerial Vehicles [Recurs electrònic] : State of the Art and the Road to Autonomy [on line]. Dordrecht: Springer Netherlands, 2007 [Consultation: 06/11/2020]. Available on: http://dx.doi.org/10.1007/978-1-4020-6114-1. ISBN 9781402061134.