IDENTIFYING DATA

Control systems

Subject	Control systems
Code	O07M189V01204
Study programme	Máster Universitario en Sistemas Aéreos no Tripulados

Descriptors	ECTS Credits		Choose	Year	Quadmester
	6		Optional	1st	2nd

Teaching language	Spanish Galician
Department	
Coordinator	García Rivera, Matías
Lecturers	García Rivera, Matías
E-mail	mgrivera@uvigo.es
Web	http://www.galiciadrones.es/
General description	This course describes fundamental concepts, principles and techniques about unmanned aerial vehicles: geometry, mechanics, hardware, control and navigation. English Friendly subject: International students may request from the teachers: a) materials and bibliographic references in English, b) tutoring sessions in English, c) exams and assessments in English.

Training and Learning Results

Code	
A3	That students are able to integrate knowledge and face the complexity of making judgments based on information that, being incomplete or limited, includes reflections on the social and ethical responsibilities linked to the application of their knowledge and judgments.
A4	That students know how to communicate their conclusions -and the ultimate knowledge and reasons that support them- to specialized and non-specialized audiences in a clear and unambiguous manner.
A5	That students possess the learning skills that will enable them to continue studying in a manner that will be largely self-directed or autonomous.
B3	That students acquire the ability to analyze the needs of a company in the field of unmanned aerial systems and determine the best technological solution for it.
B4	That students acquire the knowledge to develop unmanned aerial systems and plan specific operations, depending on the existing needs and apply the existing technological tools.
B5	That students are able to apply, in the field of unmanned aerial systems, the principles and methodologies of research such as literature searches, data collection, data analysis and interpretation, as well as the presentation of conclusions, in a clear, concise and rigorous manner.
C1	Knowledge about the main systems, on-board instruments and control station of an unmanned aircraft, as well as their influence on safety.
C3	Ability to interact with other technical teams in the engineering field for the planning of operations with unmanned aerial systems.
C4	Ability to develop a technical project in the field of unmanned aerial systems engineering.
D6	Ability to work as part of a team.
D7	Organizational and planning skills.
D8	Capacity for analysis and synthesis.
D9	Critical thinking skills and creativity.

Expected results from this subject

Expected results from this subject	Training and Learning Results

RA01: Acquire knowledge about unmanned aerial robots, their key components, state estimation, basic mechanics, design considerations, agility and maneuverability.	A3
	A4
	A5
	B3
	B4
	B5
	C1
	C3
	C4
	D6
	D7
	D8
	D9
RA03: Understand the bases of the control and navigation system, PID controls, control in 1D, 2D and 3D of multirotor, generation of trajectories, Euler-Lagrange equations and Splines.	A3
	A4
	A5
	B3
	B4
	B5
	C1
	C3
	C4
	D6
	D7
	D8
	D9
RA04: Understand the operation of multiple control systems.	A3
	A4
	A5
	B3
	B4
	B5
	C1
	C3
	C4
	D6
	D7
	D8
	D9
RA05: Know the sense & avoid devices.	A3
	A4
	A5
	B3
	B4
	B5
	C1
	C3
	C4
	D6
	D7
	D8
	D9
RA06: Understand the basics of embedded systems in real time.	A3
	A4
	A5
	B3
	B4
	B5
	C1
	C3
	C4
	D6
	D7
	D8
	D9

RA07: Know the different existing open hardware controllers and their operation.	A3
	A4
	A5
	B3
	B4
	B5
	C1
	C3
	C4
	D6
	D7
	D8
	D9

Contents

Topic	
Introduction to unmanned aerial vehicles.	Multi-rotors.
Key components of autonomous flight.	Estimation of states. Basic mechanics Design considerations Agility and maneuverability Selection of components.
Geometry and mechanics.	Transformations Rotations Angles of Euler. Quaternions Angular velocity. Newton-Euler equations. Main axes and main moments of inertia. Equations of movement of a multi-rotor. Linearization
Control and navigation.	PID control. 1D, 2D and 3D control of multirotor. Paths. Euler-Lagrange equations. Splines.
Control of multiple systems.	
Sense & avoid devices.	
Fundamentals of embedded systems in real time.	
Open hardware controllers.	

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	10	0	10
Practices through ICT	12.5	12.5	25
Mentored work	8	72	80
Seminars	3.5	3.5	7
Problem solving	12.5	12.5	25
Problem and/or exercise solving	3	0	3

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Lecturing	Exhibition by the teacher of the contents on the subject.
Practices through ICT	
Mentored work	The student, individually or in groups, prepares a document on the topic of the subject or prepares seminars, investigations, reports, essays, summaries of readings, conferences, etc.
Seminars	Orientation activity for students.
Problem solving	Activity in which problems related to the subject are formulated. The students must develop the solutions. The objective is that the students apply the theoretical contents in the resolution of small programming problems.

Personalized assistance

Methodologies	Description

	Description	Qualification	Training and Learning Results			
Practices through ICT	(*)2 entregas de prácticas autónomas a través de TIC, a ponderación de cada entrega será do 15%.	30	A3 A4 A5	B3 B4 B5	C1 C3 C4	D6 D7 D8 D9
Mentored work	1 assignment of supervised work, it will contribute 20% of the overall mark for this course	20	A3 A4 A5	B3 B4 B5	C1 C3 C4	D6 D7 D8 D9
Problem and/or exercise solving	2 written exams, short answer tests, about the contents and competences taught in the lectures and autonomous practices through ICT. These tests will be short answer, each one will contribute 25% of the overall mark for this course.	50	A3 A4 A5	B3 B4 B5	C1 C3 C4	D6 D7 D8 D9

Other comments on the Evaluation

ASSESSMENT FOR ASSISTANTS IN 1ST EDITION: CONTINUOUS EVALUATION.

For the students attending the 1st edition (continuous evaluation) the following tests and deliveries will be made:

- 1 assignment of supervised work, it will contribute 20% of the overall mark for this course;

- 2 assignments of autonomous practices through ICT, each one will contribute 15% of the overall mark for this course;

- 2 written exams, short answer tests, about the contents and competences taught in the lectures and autonomous practices through ICT. These tests will be short answer, each one will contribute 25% of the overall mark for this course.

To pass the subject it is mandatory that the student make all the assignments and all the written exams, and that in each assignment and written exam obtain a mark equal to or higher than 4.0.

In the case of not making any assignments or written exam, or obtain in any assignments or written exam a mark lower than 4.0, if the overall mark is higher than 5, the final mark in the minutes will be 4.9, fail.

ASSESSMENT FOR NON ASSISTANTS IN 1ST EDITION.

For the students attending the 1st edition (non continuous evaluation) the following tests and deliveries will be made:

- 1 assignment of supervised work, it will contribute 20% of the overall mark for this course;

- 2 assignments of autonomous practices through ICT, each one will contribute 15% of the overall mark for this course;

- 1 written exam about the contents and competences taught in the lectures and autonomous practices through ICT. This test will be short answer and it will contribute 50% of the overall mark for this course.

To pass the subject it is mandatory that the student make all the assignments and all the written exams, and that in each assignment and written exam obtain a mark equal to or higher than 4.0.

In the case of not making any assignments or written exam, or obtain in any assignments or written exam a mark lower than 4.0, if the overall mark is higher than 5, the final mark in the minutes will be 4.9, fail.

ASSESSMENT FOR 2ST EDITION AND OTHER EDITIONS

The same assessment for non assisstans in 1st edition

JUSTIFICATION OF ABSENCE

To be able to justify the absence to a exam is required a Certificate of Absence or a Consultation and Hospitalization Certificate (also called P10) issued by the SERGAS doctor, or a certificate issued by a doctor. A proof of the doctor's appointment will not be valid

Sources of information

Basic Bibliography

Randal Beard, Timothy McLain, **Small Unmanned Aircraft: Theory and Practice**, Princeton University Press, 2012

Complementary Bibliography

Michael Cook, **A Linear Systems Approach to Aircraft Stability and Control**, Butterworth-Heinemann, 2007

Katsuhiro Ogata, **Ingeniería de control moderna**, PRENTICE HALL, 2010

Hassan Gomaa, **Real-time software design for embedded systems**, Cambridge University Press, 2016

Plamen Angelov, **Sense and Avoid in UAS Research and Applications**, John Wiley &amp; Sons, Ltd, 2012

https://px4.io/,

Recommendations

Subjects that it is recommended to have taken before

Unmanned aerial systems operations/O07M174V01102

On-board sensors/O07M174V01104