



UNIVERSIDAD
POLITÉCNICA
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TEACHING
COORDINATION PROCESS
PR/CL/001



E.T.S. de Ingeniería
Aeronáutica y del Espacio

ANX-PR/CL/001-01

LEARNING GUIDE

SUBJECT

143003037 – Experimental Techniques in Fluid Mechanics

DEGREE PROGRAMME

14IB - Master of Science in Aeronautical Engineering

ACADEMIC YEAR & SEMESTER

2019/20 – First semester

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1. Description

1.1. Subject details

Name of the subject	143003037 – Experimental Techniques in Fluid Mechanics
No. of credits	3 ECTS
Type	Optional
Academic year	Second year
Semester of tuition	Third semester
Tuition period	September-January
Tuition languages	English, Spanish
Degree programme	14IB - Master of Science in Aeronautical Engineering
School/Faculty	14 - School of Aerospace Engineering (Escuela Técnica Superior de Ingeniería Aeronáutica y del Espacio)
Academic year	2019/20

2. Faculty

2.1. Faculty members with subject teaching role

Name and surname	Office/room	Email	Tutoring hours *
Benigno Lazaro Gomez (Coordinator)	C120	benigno.lazaro@upm.es	Tu - 15:00 - 18:00 Th - 15:00 - 18:00
Ezequiel Gonzalez Martinez	C119	ezequiel.gonzalez@upm.es	M - 11:30 - 14:30 W - 11:30 - 14:30

* The tutoring schedule is indicative and subject to possible changes. Please check tutoring times with the faculty member in charge.

3. Prior knowledge recommended to take the subject

3.1. Recommended (passed) subjects

- Advanced Fluid Mechanics

3.2. Other recommended learning outcomes

- Fluid Mechanics (Navier-Stokes equations and flow studies).
- Turbulent flow.
- Statistical theory and temporal series analysis.

4. Skills and learning outcomes

4.1. Skills

CE-SP-2 - Conocimiento adecuado de Mecánica de Fluidos Avanzada, con especial incidencia en las Técnicas Experimentales y Numéricas utilizadas en la Mecánica de Fluidos.

CE-SP-3 - Comprensión y dominio de los fenómenos asociados a la Combustión y a la Transferencia de Calor y Masa.

CE-SP-4 - Comprensión y dominio de las leyes de la Aerodinámica Interna. Aplicación de las mismas, junto con otras disciplinas, a la resolución de problemas complejos de Aeroelasticidad de Sistemas Propulsivos.

CE-SP-6 - Conocimiento adecuado de Aerorreactores, Turbinas de Gas, Motores Cohete y Turbomáquinas.

CE-SP-9 - Conocimiento adecuado de los distintos Subsistemas de las Plantas Propulsivas de Vehículos Aeroespaciales.

CG1 - Capacidad para proyectar, construir, inspeccionar, certificar y mantener todo tipo de aeronaves y vehículos espaciales, con sus correspondientes subsistemas.

CG10 - Conocimiento, comprensión y capacidad para aplicar la legislación necesaria en el ejercicio de la profesión de Ingeniero Aeronáutico.

CG11 - 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.

CG12 - 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.

CG13 - Ser capaz de integrar conocimientos y enfrentarse a la complejidad de formular juicios a partir de una información que, siendo incompleta o limitada, incluya reflexiones sobre las responsabilidades sociales y éticas vinculadas a la aplicación de sus conocimientos y juicios.

CG14 - 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.

CG15 - Poseer las habilidades de aprendizaje que les permitan continuar estudiando de un modo que habrá de ser en gran medida autodirigido o autónomo.

CG16 - Capacidad de integrar el respeto al medio ambiente como actitud general en la gestión y el desempeño de sus actividades.

CG3 - Capacidad para la dirección general y la dirección técnica de proyectos de investigación, desarrollo e innovación, en empresas y centros tecnológicos aeronáuticos y espaciales.

CG4 - Capacidad de integrar sistemas aeroespaciales complejos y equipos de trabajo multidisciplinares.

CG5 - Capacidad para analizar y corregir el impacto ambiental y social de las soluciones técnicas de cualquier sistema aeroespacial.

CG6 - Capacidad para el análisis y la resolución de problemas aeroespaciales en entornos nuevos o desconocidos, dentro de contextos amplios y complejos.

CG7 - Competencia para planificar, proyectar, gestionar y certificar los procedimientos, infraestructuras y sistemas que soportan la actividad aeroespacial, incluyendo los sistemas de navegación aérea.

CG8 - Competencia para el proyecto de construcciones e instalaciones aeronáuticas y espaciales, que requieran un proyecto integrado de conjunto, por la diversidad de sus tecnologías, su complejidad o por los amplios conocimientos técnicos necesarios.

CG9 - Competencia en todas aquellas áreas relacionadas con las tecnologías aeroportuarias, aeronáuticas o espaciales que, por su naturaleza, no sean exclusivas de otras ramas de la ingeniería.

CT1 - Capacidad para comprender los contenidos de clases magistrales, conferencias y seminarios, así como cualquier información y documentación en lengua inglesa.

CT2 - Capacidad para dinamizar y liderar equipos de trabajo multidisciplinares.

CT3 - Capacidad para adoptar soluciones creativas que satisfagan adecuadamente las diferentes necesidades planteadas.

CT4 - Capacidad para trabajar de forma efectiva como individuo, organizando y planificando su propio trabajo, de forma independiente o como miembro de un equipo.

CT5 - Capacidad para gestionar la información, identificando las fuentes necesarias, los principales tipos de documentos técnicos y científicos, de una manera adecuada y eficiente.

CT6 - Capacidad para emitir juicios sobre implicaciones económicas, administrativas, sociales, éticas y medioambientales ligadas a la aplicación de sus conocimientos.

CT7 - Capacidad para trabajar en contextos internacionales.

4.2. Learning outcomes

RA210 - Conocimiento de descripción estadística del flujo turbulento

RA215 - Conocimiento de técnicas de anemometría por hilo caliente y técnicas láser

RA213 - Conocimiento de técnicas de medida de presión, temperatura y flujo de calor

RA214 - Conocimiento de técnicas de anemometría neumática

RA211 - Conocimiento de estimadores estadísticos en series temporales

RA11 - Analiza críticamente los resultados obtenidos con las técnicas de medida empleadas en las prácticas de laboratorio, conoce sus límites y cotas de error.

RA209 - Conocimiento de descripción estadística de series temporales aleatorias

5. Brief description of the subject and syllabus

5.1. Brief description of the subject

Fluid mechanics plays a very important role in aeronautical and aerospace propulsion systems. The experimental techniques associated with fluid mechanics are used in different phases of the research, development, design, certification, and operation processes of these systems. The different elements are subject to such demanding requirements as to justify the implementation of experimental programs in order to understand the complex physical processes governing their fluid dynamic behavior and to optimize their response and validate numerical calculation tools used in design.

Additionally, experimental techniques are used to characterize and certify the system performance and continuously monitor their operation.

The subject is divided into three modules. Module I introduces turbulent flow measurement and application to characterization, introducing the statistics used to describe and analyse the experimental data post-processing techniques. Module II presents conventional experimental techniques, applied to propulsion systems characterization. Finally, Module III introduces advanced experimental techniques, including high resolution anemometry.

This subject focuses on the characterization of propulsion system flow, but the addressed experimental techniques can also be applied in other fields of aerospace engineering, such as flow characterization around aerodynamic bodies, as well as aerospace vehicles.

5.2. Syllabus

1. Measurement Processes in Fluid Mechanics
2. Turbulent Flow Characterization
3. Signal Conditioning and Transportation
4. Temperature and Heat Flux Measurement
5. Pressure Measurement
6. Hot Wire Anemometry
7. Laser Anemometry
8. Turbulent Flow Measurement Practices

6. Schedule

6.1. Subject schedule *

Week	Face-to-face classroom activities	Face-to-face laboratory activities	Other face-to-face activities	Assessment activities
1	Theme 1 Duration: 02:00 L: Lecture			Attendance control OT: Other assessment techniques Continuous assessment and final exam only
2	Topic 2 Duration: 02:00 L: Lecture			Attendance control OT: Other assessment techniques Continuous assessment and final exam only
3	Topic 2 Duration: 02:00 L: Lecture			Attendance control OT: Other assessment techniques Continuous assessment and final exam only
4	Topic 2 Duration: 02:00 L: Lecture			Attendance control OT: Other assessment techniques Continuous assessment and final exam only
5	Topic 2 Duration: 02:00 L: Lecture			Attendance control OT: Other assessment techniques Continuous assessment and final exam only
6	Topic 3 Duration: 02:00 L: Lecture			Attendance control OT: Other assessment techniques Continuous assessment and final exam only
7	Topic 4 Duration: 02:00 L: Lecture			Classroom attendance OT: Other assessment techniques Continuous assessment and final exam only Duration: 00:00
8	Topic 4 Duration: 02:00 L: Lecture			Attendance control OT: Other assessment techniques Continuous assessment and final exam only
9	Topic 5 Duration: 02:00 L: Lecture			Attendance control OT: Other assessment techniques Continuous assessment and final exam only
10	Topic 5 Duration: 02:00 L: Lecture			Attendance control OT: Other assessment techniques Continuous assessment and final exam only
11	Topic 5 Duration: 02:00 L: Lecture			Attendance control OT: Other assessment techniques Continuous assessment and final exam only

12	Topic 6 Duration: 02:00 L: Lecture			Attendance control OT: Other assessment techniques Continuous assessment and final exam only
13	Topic 6 Duration: 02:00 L: Lecture			Attendance control OT: Other assessment techniques Continuous assessment and final exam only
14	Topic 7 Duration: 02:00 L: Lecture			Attendance control OT: Other assessment techniques Continuous assessment and final exam only
15	Topic 7 Duration: 02:00 L: Lecture			Attendance control OT: Other assessment techniques Continuous assessment and final exam only
16		Topic 8 Duration: 03:00 PL: Laboratory Prácticas de Laboratorio		Attendance control to Laboratory OT: Other assessment techniques Continuous assessment and only final exam
17				Laboratory: Report (exam) PE: Practical exam Continuous assessment and final exam only

Independent study is an educational activity during which students should spend time on studying alone or completing individual assignments.

Depending on the curriculum schedule, total values will be calculated according to the ECTS credit unit as 26/27 hours of face-to-face contact and independent study time.

* The subject schedule is based on theoretical subject curriculum planning and could be subject to unforeseen changes throughout the academic year.

7. Activities and assessment criteria

7.1. Assessment activities

7.1.1. Continuous assessment

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Assessed skills
1	Classroom attendance	OT: Other assessment techniques	Face-to-face	00:00	3%	/ 10	CG1 CG9 CT2 CG11 CG12 CG13 CG15 CG4 CG5 CG6 CG7 CG10 CG16 CG3 CT3 CT4 CT5 CT7 CG8 CE-SP-3 CE-SP-9 CG14 CT1 CT6 CE-SP-2 CE-SP-4 CE-SP-6
							CG1 CG11 CG12 CG13 CG15 CG4 CG5 CG6 CG7 CG10 CG16 CG3 CT3

2	Classroom attendance	OT: Other assessment techniques	Face-to-face	00:00	3%	/ 10	CT4 CT5 CT7 CG8 CE-SP-3 CE-SP-9 CG14 CT1 CT6 CE-SP-2 CG9 CT2 CE-SP-4 CE-SP-6
3	Classroom attendance	OT: Other assessment techniques	Face-to-face	00:00	3%	/ 10	CG9 CT2 CG1 CG11 CG12 CG13 CG15 CG4 CG5 CG6 CG7 CG10 CG16 CG3 CT3 CT4 CT5 CT7 CG8 CE-SP-3 CE-SP-9 CG14 CT1 CT6 CE-SP-2 CE-SP-4 CE-SP-6
		OT: Otras					CG9 CT2 CG1 CG11 CG12 CG13 CG15 CG4 CG5 CG6 CG7 CG10 CG16

4	Classroom attendance	técnicas evaluativas	Face-to-face	00:00	3%	/ 10	CG3 CT3 CT4 CT5 CT7 CG8 CE-SP-3 CE-SP-9 CG14 CT1 CT6 CE-SP-2 CE-SP-4 CE-SP-6
5	Classroom attendance	OT: Other assessment techniques	Face-to-face	00:00	3%	/ 10	CG9 CT2 CG1 CG11 CG12 CG13 CG15 CG4 CG5 CG6 CG7 CG10 CG16 CG3 CT3 CT4 CT5 CT7 CG8 CE-SP-3 CE-SP-9 CG14 CT1 CT6 CE-SP-2 CE-SP-4 CE-SP-6
		OT: Other assessment					CG9 CT2 CG1 CG11 CG12 CG13 CG15 CG4 CG5 CG6 CG7 CG10 CG16

6	Classroom attendance		Face-to-face	00:00	3%	/ 10	CG3 CT3 CT4 CT5 CT7 CG8 CE-SP-3 CE-SP-9 CG14 CT1 CT6 CE-SP-2 CE-SP-4 CE-SP-6
7	Classroom attendance	OT: Other assessment techniques	Face-to-face	00:00	3%	/ 10	CG9 CT2 CG1 CG11 CG12 CG13 CG15 CG4 CG5 CG6 CG7 CG10 CG16 CG3 CT3 CT4 CT5 CT7 CG8 CE-SP-3 CE-SP-9 CG14 CT1 CT6 CE-SP-2 CE-SP-4 CE-SP-6
		OT: Other assessment					CT2 CG1 CG11 CG9 CG12 CG13 CG15 CG4 CG5 CG6 CG7 CG10 CG16

8	Classroom attendance		Face-to-face	00:00	3%	/ 10	CG3 CT3 CT4 CT5 CT7 CG8 CE-SP-3 CE-SP-9 CG14 CT1 CT6 CE-SP-2 CE-SP-4 CE-SP-6
9	Classroom attendance	OT: Other assessment techniques	Face-to-face	00:00	3%	/ 10	CG9 CT2 CG1 CG11 CG12 CG13 CG15 CG4 CG5 CG6 CG7 CG10 CG16 CG3 CT3 CT4 CT5 CT7 CG8 CE-SP-3 CE-SP-9 CG14 CT1 CT6 CE-SP-2 CE-SP-4 CE-SP-6
		OT: Other assessment					CG1 CG11 CG9 CT2 CG12 CG13 CG15 CG4 CG5 CG6 CG7 CG10 CG16

10	Classroom attendance		Face-to-face	02:00	3%	/ 10	CG3 CT3 CT4 CT5 CT7 CG8 CE-SP-3 CE-SP-9 CG14 CT1 CT6 CE-SP-2 CE-SP-4 CE-SP-6
11	Classroom attendance	OT: Other assessment techniques	Face-to-face	00:00	3%	/ 10	CG9 CT2 CG1 CG11 CG12 CG13 CG15 CG4 CG5 CG6 CG7 CG10 CG16 CG3 CT3 CT4 CT5 CT7 CG8 CE-SP-3 CE-SP-9 CG14 CT1 CT6 CE-SP-2 CE-SP-4 CE-SP-6
		OT: Other assessment					CG9 CT2 CG1 CG11 CG12 CG13 CG15 CG4 CG5 CG6 CG7 CG10 CG16

12	Classroom attendance		Face-to-face	00:00	3%	/ 10	CG3 CT3 CT4 CT5 CT7 CG8 CE-SP-3 CE-SP-9 CG14 CT1 CT6 CE-SP-2 CE-SP-4 CE-SP-6
13	Classroom attendance	OT: Other assessment techniques	Face-to-face	00:00	3%	/ 10	CG9 CT2 CG1 CG11 CG12 CG13 CG15 CG4 CG5 CG6 CG7 CG10 CG16 CG3 CT3 CT4 CT5 CT7 CG8 CE-SP-3 CE-SP-9 CG14 CT1 CT6 CE-SP-2 CE-SP-4 CE-SP-6
		OT: Other assessment					CG9 CT2 CG1 CG11 CG12 CG13 CG15 CG4 CG5 CG6 CG7 CG10 CG16

14	Classroom attendance		Face-to-face	00:00	3%	/ 10	CG3 CT3 CT4 CT5 CT7 CG8 CE-SP-3 CE-SP-9 CG14 CT1 CT6 CE-SP-2 CE-SP-4 CE-SP-6
15	Classroom attendance	OT: Other assessment techniques	Face-to-face	00:00	3%	/ 10	CG9 CT2 CG1 CG11 CG12 CG13 CG15 CG4 CG5 CG6 CG7 CG10 CG16 CG3 CT3 CT4 CT5 CT7 CG8 CE-SP-3 CE-SP-9 CG14 CT1 CT6 CE-SP-2 CE-SP-4 CE-SP-6
		OT: Other assessment					CG1 CG11 CG12 CG13 CG15 CG4 CG5 CG6 CG7 CG10 CG16 CG3 CT3

16	Practical laboratory attendance		Face-to-face	00:00	10%	/ 10	CT4 CT5 CT7 CG8 CE-SP-3 CE-SP-9 CG14 CT1 CT6 CE-SP-2 CE-SP-4 CE-SP-6 CG9 CT2
17	Practical laboratory report	PE: Practical exam	Remote	00:00	45%	5 / 10	

7.1.2. Final assessment only

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Assessed skills
1	Classroom attendance	OT: Other assessment techniques	Face-to-face	00:00	3%	/ 10	CG1 CG9 CT2 CG11 CG12 CG13 CG15 CG4 CG5 CG6 CG7 CG10 CG16 CG3 CT3 CT4 CT5 CT7 CG8 CE-SP-3 CE-SP-9 CG14 CT1 CT6 CE-SP-2 CE-SP-4 CE-SP-6

2	Classroom attendance	OT: Other assessment techniques	Face-to-face	00:00	3%	/ 10	CG1 CG11 CG12 CG13 CG15 CG4 CG5 CG6 CG7 CG10 CG16 CG3 CT3 CT4 CT5 CT7 CG8 CE-SP-3 CE-SP-9 CG14 CT1 CT6 CE-SP-2 CG9 CT2 CE-SP-4 CE-SP-6
3	Classroom attendance	OT: Other assessment techniques	Face-to-face	00:00	3%	/ 10	CG9 CT2 CG1 CG11 CG12 CG13 CG15 CG4 CG5 CG6 CG7 CG10 CG16 CG3 CT3 CT4 CT5 CT7 CG8 CE-SP-3 CE-SP-9 CG14 CT1 CT6 CE-SP-2 CE-SP-4 CE-SP-6

4	Classroom attendance	OT: Other assessment techniques	Face-to-face	00:00	3%	/ 10	CG9 CT2 CG1 CG11 CG12 CG13 CG15 CG4 CG5 CG6 CG7 CG10 CG16 CG3 CT3 CT4 CT5 CT7 CG8 CE-SP-3 CE-SP-9 CG14 CT1 CT6 CE-SP-2 CE-SP-4 CE-SP-6
5	Classroom attendance	OT: Other assessment techniques	Face-to-face	00:00	3%	/ 10	CG9 CT2 CG1 CG11 CG12 CG13 CG15 CG4 CG5 CG6 CG7 CG10 CG16 CG3 CT3 CT4 CT5 CT7 CG8 CE-SP-3 CE-SP-9 CG14 CT1 CT6 CE-SP-2 CE-SP-4 CE-SP-6

6	Classroom attendance	OT: Other assessment techniques	Face-to-face	00:00	3%	/ 10	CG9 CT2 CG1 CG11 CG12 CG13 CG15 CG4 CG5 CG6 CG7 CG10 CG16 CG3 CT3 CT4 CT5 CT7 CG8 CE-SP-3 CE-SP-9 CG14 CT1 CT6 CE-SP-2 CE-SP-4 CE-SP-6
7	Classroom attendance	OT: Other assessment techniques	Face-to-face	00:00	3%	/ 10	CG9 CT2 CG1 CG11 CG12 CG13 CG15 CG4 CG5 CG6 CG7 CG10 CG16 CG3 CT3 CT4 CT5 CT7 CG8 CE-SP-3 CE-SP-9 CG14 CT1 CT6 CE-SP-2 CE-SP-4 CE-SP-6

8	Classroom attendance	OT: Other assessment techniques	Face-to-face	00:00	3%	/ 10	CT2 CG1 CG11 CG9 CG12 CG13 CG15 CG4 CG5 CG6 CG7 CG10 CG16 CG3 CT3 CT4 CT5 CT7 CG8 CE-SP-3 CE-SP-9 CG14 CT1 CT6 CE-SP-2 CE-SP-4 CE-SP-6
9	Classroom attendance	OT: Other assessment techniques	Face-to-face	00:00	3%	/ 10	CG9 CT2 CG1 CG11 CG12 CG13 CG15 CG4 CG5 CG6 CG7 CG10 CG16 CG3 CT3 CT4 CT5 CT7 CG8 CE-SP-3 CE-SP-9 CG14 CT1 CT6 CE-SP-2 CE-SP-4 CE-SP-6

10	Classroom attendance	OT: Other assessment techniques	Face-to-face	02:00	3%	/ 10	CG1 CG11 CG9 CT2 CG12 CG13 CG15 CG4 CG5 CG6 CG7 CG10 CG16 CG3 CT3 CT4 CT5 CT7 CG8 CE-SP-3 CE-SP-9 CG14 CT1 CT6 CE-SP-2 CE-SP-4 CE-SP-6
11	Classroom attendance	OT: Other assessment techniques	Face-to-face	00:00	3%	/ 10	CG9 CT2 CG1 CG11 CG12 CG13 CG15 CG4 CG5 CG6 CG7 CG10 CG16 CG3 CT3 CT4 CT5 CT7 CG8 CE-SP-3 CE-SP-9 CG14 CT1 CT6 CE-SP-2 CE-SP-4 CE-SP-6

12	Classroom attendance	OT: Other assessment techniques	Face-to-face	00:00	3%	/ 10	CG9 CT2 CG1 CG11 CG12 CG13 CG15 CG4 CG5 CG6 CG7 CG10 CG16 CG3 CT3 CT4 CT5 CT7 CG8 CE-SP-3 CE-SP-9 CG14 CT1 CT6 CE-SP-2 CE-SP-4 CE-SP-6
13	Classroom attendance	OT: Other assessment techniques	Face-to-face	00:00	3%	/ 10	CG9 CT2 CG1 CG11 CG12 CG13 CG15 CG4 CG5 CG6 CG7 CG10 CG16 CG3 CT3 CT4 CT5 CT7 CG8 CE-SP-3 CE-SP-9 CG14 CT1 CT6 CE-SP-2 CE-SP-4 CE-SP-6

14	Classroom attendance	OT: Other assessment techniques	Face-to-face	00:00	3%	/ 10	CG9 CT2 CG1 CG11 CG12 CG13 CG15 CG4 CG5 CG6 CG7 CG10 CG16 CG3 CT3 CT4 CT5 CT7 CG8 CE-SP-3 CE-SP-9 CG14 CT1 CT6 CE-SP-2 CE-SP-4 CE-SP-6
15	Classroom attendance	OT: Other assessment techniques	Face-to-face	00:00	3%	/ 10	CG9 CT2 CG1 CG11 CG12 CG13 CG15 CG4 CG5 CG6 CG7 CG10 CG16 CG3 CT3 CT4 CT5 CT7 CG8 CE-SP-3 CE-SP-9 CG14 CT1 CT6 CE-SP-2 CE-SP-4 CE-SP-6

16	Practical laboratory attendance	OT: Other assessment techniques	Face-to-face	00:00	10%	/ 10	CG1 CG11 CG12 CG13 CG15 CG4 CG5 CG6 CG7 CG10 CG16 CG3 CT3 CT4 CT5 CT7 CG8 CE-SP-3 CE-SP-9 CG14 CT1 CT6 CE-SP-2 CE-SP-4 CE-SP-6 CG9 CT2
17	Practical laboratory report	PE: Practical exam	Remote	00:00	45%	5 / 10	

7.1.3. Referred (re_sit) examination

7.2. Assessment criteria

The assessment of the subject will include control of face-to-face activity, as well as practical assignments in the laboratory depending on the availability of experimental facilities throughout the semester.

Additionally, there will be a final test will be carried out, based on the realization of exercises or a final (individual or group) report related to the content taught in class and the practical assignments set.

The requirements for passing the subject include attendance (except justified absences approved by professors) of more than 75% of the classes and practical sessions in the laboratory, as well as submission of the final exam. As a guideline, each part of the assessment will be weighted as follows:

- Continuous assessment throughout the semester equivalent to no more than 50% of the final grade.
- Final exam on practical laboratory performance and reports equivalent to no more than 50% of the final grade.

8. Teaching resources

8.1. Teaching resources for the subject

Name	Type	Notes
Lázaro, B. Subject presentationse	Further reading	Subject presentations available in the subject Moodle space
Practical laboratory equipment	Equipment	Experimental facilities, measuring devices and data collection systems.
Albrecht, H.; Borys, M.; Damaschke, N.; Tropea, C. Laser Doppler and Phase Doppler Measurement Techniques. Springer, 2003.	Further reading	

Arts, T. (editor). Measurement Techniques in Fluid Dynamics. Von Karman Institute for Fluid Dynamics, 1994.	Further reading	
Bendat, J.; Piersol, A. Random Data. John Wiley & Sons, 2000.	Further reading	
Blackburn, J. Modern Instrumentation for Scientists and Engineers. Springer, 2001.	Further reading	
Bradshaw, P. An Introduction to Turbulence and its Measurement. Pergamon, 1975.	Further reading	
Goldstein, R. Fluid Mechanics Measurements. Hemisphere, 1996.	Further reading	
Hamming, R. Digital Filters. Prentice-Hall, 1989.	Further reading	
Horowitz, P; Hill, W. The Art of Electronics. Cambridge University Press, 1989.	Further reading	
Pope, S. Turbulent Flows. Cambridge University Press, 2000.	Further reading	
Raffel, M.; Willert, Ch.; Kompenhans, J. Particle Image Velocimetry. Springer, 2002.	Further reading	
Smits, A. J.; Lim, T. Flow Visualization. Imperial College Press, 2000.	Further reading	

9. Other information

9.1. Other information of the subject

The syllabus and assessment criteria may be subject to modifications according to the final number of enrolled students to assure effective teaching throughout the semester.