ANX-PR/CL/001-01

LEARNING GUIDE

SUBJECT

83000006 - Advanced Hydrodynamics

DEGREE PROGRAMME

08IN - Master Universitario En Ingenieria Naval Y Oceanica

ACADEMIC YEAR & SEMESTER

2024/25 - Semester 2

Index

Learning guide

1. Description

1.1. Subject details

Name of the subject	83000006 - Advanced Hydrodynamics
No of credits	4 ECTS
Type	Compulsory
Academic year ot the programme	First year
Semester of tuition	Semester 2
Tuition period	February-June
Tuition languages	English
Degree programme	08IN - Master Universitario en Ingenieria Naval y Oceanica
Centre	08 - Escuela Tecnica Superior De Ingenieros Navales
Academic year	2024-25

2. Faculty

2.1. Faculty members with subject teaching role

Name and surname	Office/Room	Email	Tutoring hours *
Antonio Souto Iglesias (Subject coordinator)	el habitual	antonio.souto@upm.es	Sin horario. ver horario en site etsin
Javier Calderon Sanchez	habitual	javier.calderon@upm.es	Sin horario. ver horario en site ETSIN

Francisco Mata Alvarez-Santullano	el habitual	francisco.mata@upm.es	Sin horario. ver horario en site ETSIN

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

2.2. Research assistants

Name and surname	Email	Faculty member in charge
Portillo Juan, Adrian	adrian.portillo.juan@upm.es	Souto Iglesias, Antonio

3. Prior knowledge recommended to take the subject

3.1. Recommended (passed) subjects

The subject - recommended (passed), are not defined.

3.2. Other recommended learning outcomes

- Conocimientos de hidrodinámica del buque

4. Skills and learning outcomes *

4.1. Skills to be learned

(K1) - Conocimiento avanzado de la hidrodinámica naval para su aplicación a la optimización de carenas, propulsores y apéndices.

CG1 - 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.

CG2 - Que los estudiantes sean capaces 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.

CG3 - 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.

CG4 - (S1) 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.

CTUPM01 - (S2) Creatividad. Los estudiantes deben resolver de forma nueva, original y aportando valor, situaciones o problemas en el ámbito de la ingeniería.

CTUPM02 - (S3) Organización y planificación. Los estudiantes fijan objetivos, con la planificación y programación de actividades (tiempo y fases) y con la organización y gestión de los recursos necesarios para alcanzarlos.

CTUPM03 - (S4) Liderazgo. Los estudiantes dirigen y coordinan personas para que trabajen con entusiasmo en la consecución de objetivos en pro del bien común.

CTUPM04 - (S5) Uso de la lengua inglesa. Los estudiantes establecen conversaciones con nativos sin tener problemas de comunicación adicionales tanto de forma oral como escrita.

CTUPM05 - (S6) Uso de las tecnologías de la información y comunicación (TIC). Los estudiantes aplican conocimientos tecnológicos necesarios de manera que les permitan desenvolverse cómodamente y afrontar los retos que la sociedad les va a imponer en su quehacer profesional empleando la informática.

CTUPM06 - (S7) Comunicación oral y escrita. Los estudiantes transmiten conocimientos y expresan ideas y argumentos de manera clara, rigurosa y convincente, tanto de forma oral como escrita, utilizando los recursos gráficos y los medios necesarios adecuadamente y adaptándose a las características de la situación y de la audiencia.

CTUPM08 - Trabajo en equipo. Los estudiantes desarrollan la capacidad para trabajar en equipo, integrarse y colaborar de forma activa en la consecución de objetivos comunes.

CTUPM09 - Resolución de problemas. Los estudiantes son capaces de identificar o proponer un problema, y tienen el conocimiento sobre diferentes alternativas metodológicas y estratégicas para resolverlo.

CTUPM13 - Trabajo en contextos internacionales. Los estudiantes son capaces de integrarse en un grupo o equipo, colaborando y cooperando con otros. Tienen la capacidad para trabajar con estudiantes de otras disciplinas y de aceptar la diversidad social y cultural.

4.2. Learning outcomes

RA10 - COMPETENCIAS: Capacidad para revisar y aplicar a la resistencia de un buque los conceptos de placa plana laminar y turbulenta

RA11 - COMPETENCIAS: Capacidad para identificar, calcular y analizar la resistencia viscosa y el efecto de forma

RA12 - COMPETENCIAS: Capacidad para identificar, calcular y analizar el efecto de la rugosidad y de los apéndices así como su extrapolación

RA13 - HABILIDADES Y DESTREZAS: Saber manejar códigos de simulación CFD para resistencia y de códigos de cálculo directo para propulsión.Aplicaciones a la Ingeniería Naval Militar.

* The Learning Guides should reflect the Skills and Learning Outcomes in the same way as indicated in the Degree Verification Memory. For this reason, they have not been translated into English and appear in Spanish.

5. Brief description of the subject and syllabus

5.1. Brief description of the subject

The course consists of two main parts: Resistance and Propulsion.

In resistance, viscous resistance and wave resistance are studied: CFD modelling and potential flow BEM solvers are discussed.

In the propulsion part, the theories of propeller operation and the design of propellers by direct calculation are studied.

Due to the timing of software training and team works related effort, some of the resistance contents are taken to a final lesson.

The face-to-face activities are designed for the conventional classroom and for the computer classroom, since support software will be used. In addition, practical activities are proposed in the ETSI Navales Towing Tank, related to the contents of the subject.

5.2. Syllabus

1. Course presentation

2. Wave resistance

   2.1. Review of basic concepts: Froude CW dependance, Hughes extrapolation, CW scaling on Fr^4, etc.

   2.2. Wave system created by a pressure point

   2.3. Interference of wave systems (bow, bulb, shoulders, etc...)

   2.4. Dawson's method for calculating the wave train of a vessel in potential flow

3. Resistencia viscosa -- Viscous resistance

   3.1. Resistencia de fricción. Placa plana y líneas de fricción. Capa límite -- Friction resistance. Flat plate and friction lines. Boundary layer

   3.2. Efecto de forma: engrosamiento de capa límite y separación -- Form effect: boundary layer thickening and separation

   3.3. Rugosidad (tipos) y apéndices (extrapolación) -- Roughness (types) and appendages (extrapolation)

   3.4. Turbulencia: conceptos y modelos -- Turbulence: concepts and models

   3.5. Medida directa de la resistencia viscosa -- Direct measurement of the viscous resistance

   3.6. CFD: conceptos, discretización, verificación, validación -- CFD: concepts, discretization, verification, validation

   3.7. Modelización CFD con un código viscoso -- CFD modeling with a viscous solver

4. Propellers: review of basic concepts: geometry, KT, KQ, etc.

5. Cavitation

   5.1. Definition

   5.2. Cavitation criteria in propeller design.

   5.3. Types of cavitation

   5.4. Cavitation tests: non-dimensional numbers

   5.5. Underwater radiation propeller noise: introduction

6. Theories on the hydrodynamics of screw propellers

6.1. Teoría simplificada de la cantidad de movimiento (1D) -- Simplified 1D momentum theory

6.2. Teoría simplificada de la cantidad de movimiento -- Simplified momentum theory

6.3. Teorías de la cantidad de movimiento del elemento de pala -- Blade element momentum theory

6.4. Teoría de circulación -- Circulation theory

6.4.1. Radial wake distribution

7. Wave Resistance Complements

7.1. Wave interference

7.2. Wave resistance calculation: Michell's method

7.3. Effects of depth on wave resistante and wave system

7.4. Squat effect

7.5. Sea trials correction due to reduced depth: Lackenby and Schlichting methods

6. Schedule

6.1. Subject schedule*

Week	Type 1 activities	Type 2 activities	Distant / On-line	Assessment activities
1	**Lesson 1** Duration: 00:30 **Lesson 2** Duration: 01:30 **Exercises** Duration: 01:00			
2	**Lesson 2** Duration: 01:00 **Exercises** Duration: 01:00	**Software training** Duration: 01:00		**Moodle task associated to SW training** Progressive assessment Presential Duration: 00:00
3	**Lesson 2** Duration: 01:00 **Exercises** Duration: 01:00	**Software training** Duration: 01:00		**Moodle task associated to SW training** Progressive assessment Presential Duration: 00:00
4	**Lesson 3** Duration: 01:00	**Software training** Duration: 02:00		**Moodle task associated to SW training** Progressive assessment Presential Duration: 00:00
5	**Lesson 3** Duration: 01:00 **Exercises** Duration: 01:00	**Software training** Duration: 01:00		**Moodle task associated to SW training** Progressive assessment Presential Duration: 00:00
6	**Lesson 3** Duration: 01:00	**Software training** Duration: 02:00		**Moodle task associated to SW training** Progressive assessment Presential Duration: 00:00

7	**Lesson 3** Duration: 01:00 **Exercises** Duration: 01:00	**Software training** Duration: 01:00		**Moodle task associated to SW training** Progressive assessment Presential Duration: 00:00
8	**Lesson 3** Duration: 01:00 **Team Work. Part 1. Presentation.** Duration: 01:00	**Software training** Duration: 01:00		**Team work. Part 1. Presentation** Progressive assessment Presential Duration: 00:00 **Moodle task associated to SW training** Progressive assessment Presential Duration: 00:00
9	**Midterm 1: Lessons 1-3** Duration: 01:00	**Software training** Duration: 02:00		**Midterm 1: Lessons 1-3** Progressive assessment Presential Duration: 00:00 **Moodle task associated to SW training** Progressive assessment Presential Duration: 00:00
10	**Lesson 4** Duration: 01:00 **Exercises** Duration: 01:00 **Lesson 5** Duration: 01:00	**Lab practice 1** Duration: 01:00 **Lab practice 2** Duration: 01:00		**Attendance and report for lab practice 1** Progressive assessment and Global Examination Presential Duration: 00:00 **Attendance and report for lab practice 2** Progressive assessment and Global Examination Presential Duration: 00:00
11	**Lesson 6** Duration: 03:00	**Lab practice 3. Cavitation tunnel at INTA-CEHIPAR** Duration: 00:00		**Attendance and report for lab practice on Cavitation at CEHIPAR cavitation tunnel. It will add 10% max to the total grade** Progressive assessment and Global Examination Presential Duration: 00:00
12	**Lesson 6** Duration: 01:00	**Software training** Duration: 02:00		**Moodle task associated to SW training** Progressive assessment Presential Duration: 00:00

13	**Lesson 6** Duration: 01:30 **Exercises** Duration: 01:30			
14	**Lesson 6** Duration: 01:00 **Exercises** Duration: 01:00	**Software training** Duration: 01:00		**Moodle task associated to SW training** Progressive assessment Presential Duration: 00:00
15	**Lesson 7** Duration: 01:00 **Exercises** Duration: 01:00 **Team Work. Part 2. Propeller Design for ship hull studied in Part 1** Duration: 01:00			**Part 2. Team work** Progressive assessment Presential Duration: 00:00 **total theory (non-lab) grade** Progressive assessment Presential Duration: 00:00 **Moodle task associated to SW training** Progressive assessment Presential Duration: 00:00
16				
17	**Global assessment tests** Duration: 02:30			**Midterm 2: lessons 4-7 (This midterm is also part of the Global Assessment Test, with the weighting shown below)** Progressive assessment Presential Duration: 00:00 **Global evaluation exam (49% lessons 1-3, 31% lessons 4-7). Midterms 1 & 2 will be taken separately.** Global examination Presential Duration: 00:00

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

7. Activities and assessment criteria

7.1. Assessment activities

7.1.1. Assessment

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
2	Moodle task associated to SW training		Face-to-face	00:00	1%	0 / 10	CTUPM05 (K1) CTUPM04
3	Moodle task associated to SW training		Face-to-face	00:00	3%	0 / 10	
4	Moodle task associated to SW training		Face-to-face	00:00	1%	0 / 10	CTUPM05 (K1) CTUPM04
5	Moodle task associated to SW training		Face-to-face	00:00	1%	0 / 10	CTUPM05 (K1) CTUPM04
6	Moodle task associated to SW training		Face-to-face	00:00	3%	0 / 10	
7	Moodle task associated to SW training		Face-to-face	00:00	1%	0 / 10	CTUPM05 (K1) CTUPM04
8	Team work. Part 1. Presentation		Face-to-face	00:00	18%	0 / 10	CTUPM02 CTUPM03 CTUPM04 CTUPM05 CTUPM06 CTUPM09 CTUPM13 CTUPM08 (K1)
8	Moodle task associated to SW training		Face-to-face	00:00	1%	0 / 10	CTUPM05 (K1) CTUPM04
9	Midterm 1: Lessons 1-3		Face-to-face	00:00	18%	3 / 10	CG1 CG2 CG3 CG4 CTUPM04 CTUPM05 CTUPM09 CTUPM01 (K1)

9	Moodle task associated to SW training		Face-to-face	00:00	3%	0 / 10	
10	Attendance and report for lab practice 1		Face-to-face	00:00	10%	5 / 10	CG1 CTUPM02 CTUPM03 CTUPM04 CTUPM05 CTUPM06 CTUPM13 CTUPM08 (K1)
10	Attendance and report for lab practice 2		Face-to-face	00:00	10%	5 / 10	CG1 CTUPM02 CTUPM03 CTUPM04 CTUPM05 CTUPM06 CTUPM13 CTUPM08 (K1)
11	Attendance and report for lab practice on Cavitation at CEHIPAR cavitation tunnel. It will add 10% max to the total grade		Face-to-face	00:00	%	0 / 10	CTUPM03 CTUPM04 CTUPM05 CG1 CTUPM02 CTUPM06 CTUPM13 CTUPM08 (K1)
12	Moodle task associated to SW training		Face-to-face	00:00	2%	0 / 10	
14	Moodle task associated to SW training		Face-to-face	00:00	1%	0 / 10	CTUPM05 (K1) CTUPM04
15	Part 2. Team work		Face-to-face	00:00	12%	0 / 10	CTUPM02 CTUPM03 CTUPM04 CTUPM05 CTUPM06 CTUPM09 CTUPM13 CTUPM08 (K1)
15	total theory (non-lab) grade		Face-to-face	00:00	%	5 / 10	CG2 CG3 CG4 (K1) CG1

15	Moodle task associated to SW training		Face-to-face	00:00	1%	0 / 10	CTUPM05 (K1) CTUPM04
17	Midterm 2: lessons 4-7 (This midterm is also part of the Global Assessment Test, with the weighting shown below)		Face-to-face	00:00	14%	3 / 10	CG1 CG2 CG3 CG4 CTUPM04 CTUPM05 CTUPM09 CTUPM01 (K1)

7.1.2. Global examination

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
10	Attendance and report for lab practice 1		Face-to-face	00:00	10%	5 / 10	CG1 CTUPM02 CTUPM03 CTUPM04 CTUPM05 CTUPM06 CTUPM13 CTUPM08 (K1)
10	Attendance and report for lab practice 2		Face-to-face	00:00	10%	5 / 10	CG1 CTUPM02 CTUPM03 CTUPM04 CTUPM05 CTUPM06 CTUPM13 CTUPM08 (K1)
11	Attendance and report for lab practice on Cavitation at CEHIPAR cavitation tunnel. It will add 10% max to the total grade		Face-to-face	00:00	%	0 / 10	CTUPM03 CTUPM04 CTUPM05 CG1 CTUPM02 CTUPM06 CTUPM13 CTUPM08 (K1)
17	Global evaluation exam (49% lessons 1-3, 31% lessons 4-7). Midterms 1 & 2 will be taken separately.		Face-to-face	00:00	80%	5 / 10	CG1 CG2 CG3 CG4 CTUPM02 CTUPM03 CTUPM04 CTUPM05 CTUPM06

							CTUPM09 CTUPM01 (K1)

7.1.3. Referred (re-sit) examination

Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
Final Exam + Laboratory Practices. This assessment is a repetition of the ?global evaluation exam? assessment.		Face-to-face	02:00	100%	5 / 10	CG1 CG2 CG3 CTUPM01 CTUPM06 CG4 CTUPM02 CTUPM03 CTUPM04 CTUPM05 CTUPM13 CTUPM09 (K1) CTUPM08

7.2. Assessment criteria

A rubric is provided for assesing group works:

Moodle thread: number of entries, quality, periodicity, documenting the context of the choice, references, etc., uploading files before the presentation 30%.

Defence, assessing the technical aspects of the work, its depth, the presentation file, quality of the defence, ability to answer the questions (all members of the group can answer them), etc... 70%

Regarding Moodle, a single thread will be maintained for both DB (Ship Dynamics) and HAB (Advanced Ship Hydrodynamics) teamworks. It will be in HAB Moodle space.

If the Head of Studies (at the request of a student) indicates that an absence from a practical is justified, the following measures will be taken:

1 First of all, this student will be formally withdrawn from the corresponding group.

2 A video will be shown to the person in question, some information will be given to him/her, and a short script of the practical will be given to him/her.

3. The person in question will have to make the corresponding analysis and practice report.

4. They will also be given an article from a scientific journal that has a connection with the internship and will be asked to summarise it in 600-800 words, highlighting the connections between the article and the topic of the internship.

If the Head of Studies considers that the absence is not justified in the ordinary exam session, you will fail the practicals for not attending, with all that this implies with respect to the ordinary exam session.

In this case, in the extraordinary exam, if the person indicates that they want to attend, they will be offered exactly the same proposal as if the absence were justified.

***

In the global assessment test in the ordinary exam and in the final exam in the extraordinary exam, there will be NO minimum grade for the theory part. However, both in these two tests and in the progressive assessment, the minimum grade for the theory (everything except the practical) is 5/10 of that part, and the minimum grade for the laboratory practices is 5/10 of that part, i.e. theory and laboratory do not compensate each other: you have to pass both items.

All laboratory practices must be passed.

The overall assessment test in the ordinary exam and the final exam in the extraordinary exam will consist of two parts with the weight indicated above.

There will also be the simulation of considering the parts of the final as a progressive/continuous assessment with all that this implies.

The maximum of both will be taken.

The grade corresponding to Midterm 1 taken in the "Global Assessment Test" will NOT be kept for the Extraordinary Examination.

***

For the submission and defense of group works, several submission windows will be opened in coordination with the students' various duties.

The Extraordinary Examination functions as an exact repetition of the Global Assessment Test in the Ordinary Examination.

The only exception is that the student may wish not to take the second midterm, in case he/she wants to keep that grade.

If one of the parts ("laboratory practices" and "the rest") is failed, the student will get the grade corresponding to the

failed part. Therefore, the maximum grade in the global and progressive evaluation if one part is failed is the minimum of both parts.

--

For assignments, a Moodle task will be enabled for uploading evidence of completion. Failure to do so within the established deadline cannot be remedied.

8. Teaching resources

8.1. Teaching resources for the subject

Name	Type	Notes
Apuntes y presentaciones de todas las clases. Ver Moodle.	Bibliography	
E.V. Lewis, Principles of Naval Architecture. 2ª Revisión, SNAME. 1988..	Bibliography	
J. A. Aláez Zazurca, Resistencia Viscosa de buques, Canal de Experiencias Hidrodinámicas de El Pardo, Madrid, 1972	Bibliography	
H. S. Saunders, Hydrodynamics in Ship Design, SNAME, New York, 1965, Vol 1, 2 y 3.	Bibliography	
A. Baquero, Teorías del funcionamiento de la hélice, Apuntes de la E.T.S. de Ingenieros Navales (2012)	Bibliography	
J. Carlton, Marine Propellers and Propulsion, Butterworth-Heinemann Ltf, 1994.	Bibliography	

Molland, Ship Resistance and Propulsion	Bibliography	Molland
Souto Iglesias, Antonio (2001). Nuevas herramientas de diseño de formas de buques basadas en códigos de flujo potencial. Thesis (Doctoral), E.T.S.I. Navales (UPM).	Bibliography	
ETSIN-CFD	Others	Sw for modeling potential flow around a hull, with free surface (BEM - panel method)
Paraview	Others	Sw para postprocesing CFD and BEM method results
Salome	Others	Sw for meshing for BEM solver
OpenPROP	Others	Sw for direct calculation with circulation theory.
OpenFOAM	Others	Sw for CFD simulation
JSDN	Others	SW propeller design with systematic series.
Newman, Marine Hydrodynamics	Bibliography	

9. Other information

9.1. Other information about the subject

The timetable follows a theoretical planning of the subject that may undergo minor modifications during the course.

Attendance sheets will be signed for the laboratory practicals, as well as for the different evaluable tasks.

The software sessions may take place at any class time or in the common time. They will be announced in advance.

For the team works, prior to the defence, the required files (presentation, software, etc.) will be handed in.

****

Goals and targets (of the 2030 Agenda for Sustainable Development)

Goal 2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture

2.3 By 2030, double the agricultural productivity and incomes of small-scale food producers, particularly women, indigenous peoples, family farmers, livestock keepers and fishers, including through secure and equitable access to land, other productive resources and inputs, and knowledge, financial services, markets and opportunities for value addition and off-farm employment.

The course prepares students for better fishing vessel designs, which has an impact on this goal. In fact, the course coordinator has participated in 2023 in a UN-FAO project to improve the energy efficiency of artisanal fishing vessels for developing countries.

Goal 4. To ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.

4.3 By 2030, ensure equal access for all men and women to quality technical, vocational and higher education, including university education

This objective is being pursued by seeking to train men and women equally in the technical training associated with the subject.

Goal 5. Achieve gender equality and empower all women and girls

5.1 End all forms of discrimination against all women and girls everywhere.

This objective is pursued by seeking to train men and women equally in the technical training associated with the subject.

5.5 Ensure women's full and effective participation and equal opportunities for leadership at all levels of decision-making in political, economic, and public life.

The participation of women in presentations as well as other activities, such as debates, with a public exposure component, will be promoted.

Goal 8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all.

8.9 By 2030, develop and implement policies to promote sustainable tourism that creates jobs and promotes local culture and products.

The nautical sector is of great importance for tourism in Spain. The challenges of the subject have an impact on the design of more sustainable recreational boats for tourist use.

Goal 14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development.

14.b Facilitate artisanal fishermen's access to marine resources and markets.

The course prepares students for better fishing vessel designs, which has an impact on this goal. In fact, the course coordinator has participated in 2023 in a UN-FAO project to improve the energy efficiency of artisanal fishing vessels for developing countries.