ANX-PR/CL/001-01

LEARNING GUIDE

SUBJECT

83000087 - Hydrodynamics Of Hulls And Propellers (split)

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	83000087 - Hydrodynamics Of Hulls And Propellers (Split)
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 general de tutorías.
Javier Calderon Sanchez	El habitual	javier.calderon@upm.es	Sin horario. Ver horario general de tutorías.

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. Skills and learning outcomes *

3.1. 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.

3.2. 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

RA15 - COMPETENCIAS: Capacidad para identificar, calcular y analizar el efecto de los apéndices así como su extrapolación

RA16 - HABILIDADES Y DESTREZAS: Saber manejar software de métodos semiempíricos de estimación de resistencia

RA17 - HABILIDADES Y DESTREZAS: Saber manejar dicho software para optimización de dimensiones principales de las carenas

RA18 - HABILIDADES Y DESTREZAS: Saber manejar software de diseño y optimización de propulsores mediante series sistemáticas

RA14 - COMPETENCIAS: Capacidad para identificar,calcular y analizar las diferentes componentes de la resistencia al avance de un buque

* 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.

4. Brief description of the subject and syllabus

4.1. Brief description of the subject

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

The first part deals with the different elements that make up the resistance of a ship at a certain speed, which would allow the ship to obtain its towing power.

The second part focuses on the design of the propulsion propeller that would allow the ship to move forward at that speed. The classes will take place in the classroom and in the computing centre.

As a final part of the course, there will be a lesson dedicated to shallow depth effects: squat and sea trial effects.

The course also has practical sessions in the ETSI Naval Towing tank, related to the contents of the course.

In addition, students will be offered the possibility of doing an internship in the Cavitation Tunnel of "Canal de Experiencias Hidrodinámicas de El Pardo".

Also, this subject will be worked together with the Advanced Hydrodynamics of the Vessel in terms of team work. It should be noted that both courses are the split of the higher-level course ?Ship Hydrodynamics? in this study plan.

4.2. Syllabus

1. Hydrodynamic forces: shear and normal stresses
    1.1. Resistance from stresses integral. Form Drag.
    1.2. Ship resistance and its components. Order of magnitude of Friction drag
    1.3. Dimensional analysis
    1.4. Methodologies to estimate ship resistance.
2. Viscous resistance
    2.1. Boundary layer thickness
    2.2. Flat plate frictional resistance.
        2.2.1. Laminar solution. Blasius
        2.2.2. Turbulent solution. Friction lines. ITTC 57
    2.3. Separation or detachment of the boundary layer
3. Wave resistance
    3.1. Scaling of wave resistance. Integral formulation
    3.2. Interference effects
    3.3. Wigley experiments
    3.4. Kelvin wave system
4. Model-vessel correlation methods
    4.1. Froude correlation method
    4.2. Hughes correlation method

4.3. Methods for the experimental determination of the form factor

4.4. ITTC-78 Recommendations

4.5. Semi-empirical methods for resistance estimation: Holtrop and others

4.6. Systematic Series for Hull Design

5. Influence of vessel dimensions and shapes on resistance

5.1. Main dimensions and dimensionless relationships

5.2. Influence of the sectional area curve

5.3. Influence of the longitudinal position of the center of buoyancy

5.4. Influence of waterplane

6. Bulbous bow. Transversal sections

6.1. Bulbous bow. Functional considerations.

6.2. Influence of hull shape

7. Power types and propeller geometry

7.1. Propeller fundamentals as a propulsive element: thrust and torque

7.2. Power types and efficiencies: general description

7.3. Helical surfaces

7.4. Graphical representation of the propeller

7.5. Geometrical relations

7.6. Velocity and force diagram in a radial section of a propeller.

8. Propeller in open water conditions

8.1. Dimensionless parameters. KT, KQ diagrams

8.2. Influence of the Reynolds number

9. Hull-propeller interaction

9.1. Wake Fraction

9.2. Thrust deduction fraction

9.3. Relative rotative efficiency

9.4. Quasi-propulsive Efficiency

9.5. Self-propulsion test.

9.5.1. Friction deduction correction.

9.5.2. Effective Wake. Thrust identity

10. Cavitation

10.1. Definition

10.2. Local cavitation number

10.3. Influence of expanded area ratio on cavitation

10.4. Cavitation criteria: Keller & Burrill.

11. Systematic propeller series

11.1. Wageningen B-screw series

11.2. Gawn series

11.3. Gawn-Burrill series

11.4. Newton-Rader series

12. Manual design of a propeller using systematic series.

12.1. Design scenarios

12.1.1. Theoretical Limit to propeller efficiency based on axial momentum theory.

12.2. Hull-engine-propeller coupling in manual calculation / Motor curves / available torque check

13. Off-design conditions.

13.1. Bollard Pull and Trawling Conditions.

13.2. RPM reduction

13.3. Increase of resistance due to fouling.

14. Shallow-water conditions and ship resistance.

14.1. Squat / Barrass method

14.2. Sea trials / Lackenby and Schlichting Methods.

15. Nozzled Propellers

15.1. Fundamentals: Nozzle forces.

15.2. Wageningen Nozzled propeller series

5. Schedule

5.1. Subject schedule*

Week	Type 1 activities	Type 2 activities	Distant / On-line	Assessment activities
1	**Course presentation** Duration: 01:00 **Lesson 1** Duration: 02:00			
2	**Lessons 1 & 2** Duration: 02:00 **Exercises.** Duration: 01:00			
3	**Lesson 2.** Duration: 01:00	**Software to estimate resistance.** Duration: 02:00		**Associated Moodle Task. Resistance Software** Progressive assessment Presential Duration: 00:00
4	**Lesson 2** Duration: 02:00 **Exercises** Duration: 01:00			
5	**Lesson 3** Duration: 01:00 **Exercises** Duration: 02:00			
6	**Lesson 4.** Duration: 01:00 **Exercises** Duration: 02:00			
7	**Lessons 5, 6** Duration: 02:00 **Team Work. Part 1. Presentation. Ship resistance estiamation for a case study specific for each group.** Duration: 01:00			**Team Work. Part 1. Presentation. Ship resistance estimation for a case study specific for each group.** Progressive assessment Presential Duration: 00:00

8	**Visit to CEHIPAR** Duration: 02:00 **Midterm1. Lessons 1-6** Duration: 01:00	**Resistance test** Duration: 01:00		**Midterm1. Lessons 1-6** Progressive assessment Presential Duration: 00:00
9	**Lesson 7** Duration: 01:00 **Lesson 8** Duration: 01:00 **Exercises** Duration: 01:00	**Open water tests. Lab Practice** Duration: 01:00		
10	**Lesson 9.** Duration: 03:00	**Self-Propulsion test. Lab practice.** Duration: 01:00		
11	**Lesson 10** Duration: 01:00 **Lesson 11** Duration: 01:00 **Exercises.** Duration: 01:00			**Attendance and report of Cavitation Practice at CEHIPAR. It will be graded 10% maximu tu be added to the total grade.** Progressive assessment and Global Examination Presential Duration: 00:00
12	**Lesson 12** Duration: 01:00	**Software to design propeller** Duration: 02:00		**Associated Moodle Task. Propeller design software** Progressive assessment Presential Duration: 00:00
13	**Lesson 13** Duration: 02:00			
14	**Lesson 14** Duration: 02:00 **Prácticas y Ejercicios** Duration: 01:00			
15	**Exercises.** Duration: 02:00 **Team Work Part 2. Presentation. Propeller design for the same case like Team Work Part 1.** Duration: 01:00			**Team Work. Part 2. Presentation. Propeller design for Part 1 case study.** Progressive assessment Presential Duration: 00:00

16				**Lab practices** Progressive assessment and Global Examination Presential Duration: 00:00 **Progressive Assessemnt. Total Grade of Theory (non-lab) part Grade obtained with the weights described abve, excluding ETSIN lab practices.** Progressive assessment Presential Duration: 00:00
17	**Global evaluation test. Midterm 1** Duration: 01:00 **Midterm 2: lessons 7- end. This exam is also part of the global assessmen test.** Duration: 01:00			**Midterm 2: lessons 7- end. This exam is also part of the global assessmen test.** Progressive assessment Presential Duration: 00:00 **Global evaluation test. Midterms 1 & 2 will be taken separately. Their relative weight will be the same** 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.

6. Activities and assessment criteria

6.1. Assessment activities

6.1.1. Assessment

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
3	Associated Moodle Task. Resistance Software		Face-to-face	00:00	5%	0 / 10	CTUPM04 CTUPM05 (K1)
7	Team Work. Part 1. Presentation. Ship resistance estimation for a case study specific for each group.		Face-to-face	00:00	10%	0 / 10	CTUPM04 CTUPM09 CTUPM02 CTUPM03 CTUPM06 CTUPM05 (K1) CTUPM13 CTUPM08
8	Midterm1. Lessons 1-6		Face-to-face	00:00	22.5%	3 / 10	CG1 CG2 CG3 CG4 CTUPM04 CTUPM05 CTUPM09 CTUPM01 (K1)
11	Attendance and report of Cavitation Practice at CEHIPAR. It will be graded 10% maximu tu be added to the total grade.		Face-to-face	00:00	0%	0 / 10	CG1 CG2 CG3 CG4 CTUPM02 CTUPM03 CTUPM04 CTUPM05 CTUPM06 CTUPM09 CTUPM01 CTUPM08 (K1) CTUPM13

12	Associated Moodle Task. Propeller design software		Face-to-face	00:00	5%	0 / 10	CTUPM04 CTUPM05 (K1)
15	Team Work. Part 2. Presentation. Propeller design for Part 1 case study.		Face-to-face	00:00	10%	0 / 10	CTUPM04 CTUPM09 CTUPM02 CTUPM03 CTUPM06 CTUPM05 (K1) CTUPM13 CTUPM08
16	Lab practices		Face-to-face	00:00	25%	5 / 10	CG1 CTUPM03 CTUPM06 CTUPM05 (K1) CTUPM13 CTUPM08 CTUPM04 CTUPM02
16	Progressive Assessemnt. Total Grade of Theory (non-lab) part Grade obtained with the weights described abve, excluding ETSIN lab practices.		Face-to-face	00:00	%	5 / 10	CG1 CG2 CG4 CG3 (K1)
17	Midterm 2: lessons 7- end. This exam is also part of the global assessmen test.		Face-to-face	00:00	22.5%	3 / 10	CG1 CG2 CG3 CG4 CTUPM04 CTUPM05 CTUPM09 CTUPM01 (K1)

6.1.2. Global examination

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
11	Attendance and report of Cavitation Practice at CEHIPAR. It will be graded 10% maximu tu be added to the total grade.		Face-to-face	00:00	0%	0 / 10	CG1 CG2 CG3 CG4 CTUPM02 CTUPM03 CTUPM04 CTUPM05 CTUPM06 CTUPM09 CTUPM01 CTUPM08

							(K1) CTUPM13
16	Lab practices		Face-to-face	00:00	25%	5 / 10	CG1 CTUPM03 CTUPM06 CTUPM05 (K1) CTUPM13 CTUPM08 CTUPM04 CTUPM02
17	Global evaluation test. Midterms 1 & 2 will be taken separately. Their relative weight will be the same		Face-to-face	00:00	75%	5 / 10	CG1 CG2 CG3 CG4 CTUPM02 CTUPM03 CTUPM04 CTUPM05 CTUPM06 CTUPM09 CTUPM01 (K1)

6.1.3. Referred (re-sit) examination

Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
Exam + Lab Practice. Assessment method is a repetition of Global Examination (Ordinary call) with same minimum grades for theory and lab practices (both need be passed as in the Global Examination - Ordinary Call)		Face-to-face	02:00	100%	5 / 10	CTUPM09 CTUPM02 CG1 CTUPM04 CTUPM01 CG2 CG4 CG3 CTUPM03 CTUPM06 CTUPM05 (K1) CTUPM13 CTUPM08

6.2. Assessment criteria

Visit to CEHIPAR and subsequent report provide up to 0.5p on top the grade.

Caviation practice in CEHIPAR and subsequent report provide up to 1p on top the grade.

A rubric is provided for group work, assessing:

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

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

For the submission and defense of group works, several submission windows will be opened.

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 mark.

The grade of the first midterm in the ordinary final is not retained but the grade of the first midterm is retained for the exam taken during the course, around week 8.

If one of the parts ("laboratory practicals" and "the rest") is failed, the student will get the mark corresponding to the failed part. Therefore, the maximum mark 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.

The global evaluation test in the ordinary call and the final exam in the extraordinary call will have two parts (midterm 1 and 2).

In the global evaluation test in the ordinary call and in the final exam in the extraordinary call there will be NO minimum grade in the parts of the theory part, but it remains that the minimum grade for the theory is 5, and for the laboratory practices is 5, that is, theory and laboratory do not compensate each other: you have to pass both items.

In the global evaluation test in the ordinary call and in the final exam in the extraordinary call, the simulation of considering the parts of the final as a progressive evaluation with all that this implies will be made. The maximum of the grade of both scenarios will be taken. In the presentation of the course, examples of these scenarios will be presented so that the grading scheme is clearer and students can make the corresponding decisions.

In case of medical (or any other type of justification after evaluation by the head of studies) that prevents the realization of the laboratory practice(s), the person in question will participate in the report in the way agreed with his group. If the group approves the report, the practical will be graded with a 5. The student must also submit a small work related to the practical proposed by the teacher in charge.

The practices of resistance test, open-water propeller and self-propulsion will be carried out in ETSIN towing tank, by groups of students.

Prior to the realization of the practices, the students will carry out a "questionnaire" on the contents of the practice. Afterwards, the students will write the corresponding reports which, once evaluated, will contribute to the corresponding percentage of the final grade of the course.

Regarding the practical grade:

50% = Reports: (trailer + isolated propellant +2*car)/4

50% = average of the pre-practice tests (V/F tests).

All three practices must be attended and the reports must be approved.

The towing and open water reports are in group.

The self-propulsion report is individual.

If the lab grade is a pass, such grade is KEPT FROM ONE academic year TO ANOTHER IF THE COURSE IS FAILED.

7. Teaching resources

7.1. Teaching resources for the subject

Name	Type	Notes
Apuntes de la Asignatura de D. Antonio Baquero Mayor	Bibliography	
Principles of Naval Architecture. SNAME	Bibliography	
Manual de Prácticas de Laboratorio de Luis Perez Rojas	Bibliography	
Ship Resistance and Propulsion de A. Molland	Bibliography	
Marine Propellers and Propulsion, de J.Carlton	Bibliography	
Presentations used during the Lessons.	Bibliography	
Holtrop method	Bibliography	Holtrop, J., 1992, Hydrodynamics in ship design : training course. Wageningen Holanda Marin (ejemplar en biblioteca ETSIN) (documento interesante en general, y con una parte sobre métodos semi-empíricos).

Maxsurf Resistance	Others	Software
FreeCAD	Others	Software
JSDN	Others	Propeller Software

8. Other information

8.1. Other information about the subject

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

Attendance sheets will be signed for the laboratory sessions, 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.

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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.