Degree competences to which the subject contributes

Basic:
CB6. Possess knowledge and understanding that provide a basis or opportunity to be original in the development and / or application of ideas, often in a research context.
CB10. Students must possess the learning skills that enable them to continue studying in a way that will be largely self-directed or autonomous.
CB9. That students can communicate their conclusions and the knowledge and latest rationale underpinning to specialists and non-specialty clearly and unambiguously.

Specific:
CE2. (ENG) Conocimiento avanzado de la hidrodinámica naval para su aplicación a la optimización de carenas, propulsores y apéndices.

Teaching methodology
Activities will be carried out so that the students know how to apply their knowledge to their work or vocation in a professional way and possess the necessary skills through the elaboration and defense of arguments and problem solving within their area of study, aiming at acquiring the following capabilities:
1. Being responsible for self-learning, and being able to learn independently and continuously, being self-demanding and knowing how to define achievable goals.
2. Be able to analyze the current state of a discipline.
3. Develop critical and self-critical skills.
4. Acquire habits and skills to work responsibly in a team, possess negotiation and leadership skills, and be able to propose constructive solutions to potential conflicts.
5. Be able to weigh and manage information effectively, and know how to apply information and communication technologies to your management and analysis.
6. To be fluent in oral and written communication.

Learning objectives of the subject
1. Be able to manage and understand the vocabulary and concepts of fluid mechanics and other related scientific fields, and communicate them with the appropriate form and rigor.
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2. Demonstrate knowledge about the theories and concepts on which fluid mechanics is based.
3. Know and apply the bases of fluid mechanics in the design processes of naval and ocean structures.
4. Be able to apply the techniques and calculation methods applicable to naval and ocean structures.
5. Be able to understand and incorporate contributions of engineering to the approach and resolution of problems in the field of fluid mechanics, and to develop collaborative skills.

<table>
<thead>
<tr>
<th>Study load</th>
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<tbody>
<tr>
<td><strong>Total learning time:</strong> 45h</td>
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</table>
## Content

<table>
<thead>
<tr>
<th>Topic 1. Introduction to the concept of turbulence</th>
<th>Learning time: 27h</th>
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</thead>
<tbody>
<tr>
<td>Description:</td>
<td></td>
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<tr>
<td>The subject begins with a review of basic concepts in fluid mechanics, and then introduces the concept of turbulence, from a phenomenological point of view: vorticity and the origin of chaos and effect of viscosity. Formulation of the Reynolds equations, the Reynolds stress equations and the approach to the closure problem. Approach of some algebraic models of turbulence.</td>
<td>Theory classes: 7h</td>
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<td>Self study: 20h</td>
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<table>
<thead>
<tr>
<th>Topic 2. Flow around bodies</th>
<th>Learning time: 32h</th>
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<tbody>
<tr>
<td>Description:</td>
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<tr>
<td>In this subject an analysis of the problems of external flows is made. After introducing the problem from a phenomenological point of view, considering the effect of the Reynolds number and the geometry type, the concept of the boundary layer is revised to obtain the Prandtl equations. The solutions of these equations are then analyzed in the different flow regimes for flat plates, and the effect of the pressure gradient on the development of the boundary layer is described. Then some comments will be made regarding the effect of the free surface on the flow around bodies. The potential flow problem is then reviewed and different simple analytical results are analyzed. Finally, some general comments are made regarding the experimental study of this type of problems.</td>
<td>Theory classes: 7h</td>
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<td>Guided activities: 5h</td>
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<td>Self study: 20h</td>
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</tbody>
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<tr>
<th>Topic 3. Experimental methods in naval and ocean engineering</th>
<th>Learning time: 25h</th>
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<tbody>
<tr>
<td>Description:</td>
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<tr>
<td>The subject begins with a review of basic concepts related to dimensional analysis. Then, the most typical experimental methods used in naval and offshore engineering are presented in detail: towing test in still water (stability experiment), propeller test, self propulsion test, balance extinction test, stabilizer test, dynamics in waves, maneuverability test). The subject is completed with the realization of some practices in the ETSIN-UPM channel, corresponding to the towing test and balance extinction.</td>
<td>Theory classes: 5h</td>
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<tr>
<td></td>
<td>Laboratory classes: 5h</td>
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<tr>
<td></td>
<td>Guided activities: 5h</td>
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<tr>
<td></td>
<td>Self study: 10h</td>
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</tbody>
</table>
**Topic 4. Introduction to numerical methods in naval and offshore engineering**

**Learning time:** 33h  
Theory classes: 5h  
Practical classes: 10h  
Guided activities: 3h  
Self study: 15h

**Description:**  
The subject aims to make a revision of the different methods of numerical analysis (or CFD for Computational Fluid Dynamics) for problems in naval and offshore engineering. A brief review of the different types of physical models used (from the potential flow, to direct solution models of the Navier-Stokes equations, to the LES or RANSE methods) will be done. Then the basic numerical techniques used by these codes will be reviewed for the resolution of the equations. It will be highlighted the difficulty of treating the turbulence and some of the models used for this purpose will be reviewed. Finally some general indications for using these tools will be given. The subject is completed with the realization of practices with a CFD program, corresponding to the study of a simple 2D case and the turbulence around a body.

**Temas 5. Hydro-mechanics of propellers**

**Learning time:** 17h  
Theory classes: 5h  
Guided activities: 2h  
Self study: 10h

**Description:**  
The subject aims to review the concepts and theory of fluid mechanics related to naval propulsion. First, the basic theory of fluid mechanics applied to turbomachinery will be reviewed. Then the basic principles of the impulsion theory will be presented. Finally a review of the circulation theory applied to propellers will be presented. The theme will be completed with various practical exercises, which will be used to discuss the main aspects of cavitation and hull-propeller interaction.

**Qualification system**

The final mark is the sum of the following partial marks:  
\[ N_{\text{final}} = 0.3 \cdot N_{\text{ef}} + 0.3 \cdot N_{\text{ep}} + 0.2 \cdot N_{\text{pe}} + 0.2 \cdot N_{\text{pc}} \]

\[ N_{\text{final}}: \text{Final mark} \]
\[ N_{\text{ef}}: \text{Final exam mark} \]
\[ N_{\text{ep}}: \text{Partial exam mark} \]
\[ N_{\text{pe}}: \text{Mark of the practices in model basin} \]
\[ N_{\text{pc}}: \text{Mark of the practices with CFD} \]
Regulations for carrying out activities

Theory classes
These classes develop the theoretical concepts on the main topics of fluid mechanics of the course. The main objective of these classes is to deal with concepts that may be confusing for the students and provide them with a reference guide for the follow-up of the course.

Practices
Throughout the course different practices in group will be carried out. A report of the work done must be submitted in the given deadline. Any work not delivered or delivered out of time will be marked as 0.

Directed Activities
The class will proceed to indicate the necessary work to solve practical questions that the students will have to develop later.

Tutorials
The tutorial action will be carried out offering availability through e-mail. Although the computer tools allow a completely virtual tutoring, will be informed about the hours of the teacher's visit at the beginning of the course.

Exams
There will be a partial exam that will cover the first two subjects of the subject and one final that will cover the whole of the subject. Students who have passed the partial exam will only be able to examine the last two subjects on the final exam. The use of one paper with formulas will be allowed to carry out the exercises of application of the exams. It will be classified as not presented to the student who does not attend any of the exams called.

Bibliography

Basic:

Complementary: