Course guide
280807 - 280807 - Advanced Hydrodynamics

Last modified: 14/01/2024

Unit in charge: Barcelona School of Nautical Studies
Teaching unit: 742 - CEN - Department of Nautical Sciences and Engineering.

Degree: MASTER'S DEGREE IN NAVAL AND OCEAN ENGINEERING (Syllabus 2017). (Compulsory subject).

Academic year: 2023 **ECTS Credits:** 5.0 **Languages:** Spanish

LECTURER

Coordinating lecturer: IRENE BERDUGO PARADA

Others: Segon quadrimestre:
IRENE BERDUGO PARADA - MUENO

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
MUENO_CE1. Ability to design ships suitable for the needs of the maritime transport of people and goods, and those of maritime defense and security
MUENO_CE2. Advanced knowledge of naval hydrodynamics for its application to the optimization of hulls, thrusters and appendages
MUENO_CE3. Knowledge of the dynamics of the ship and of the naval structures, and ability to perform optimization analysis of the structure, the integration of the systems on board, and the behavior of the ship at sea and its maneuverability
MUENO_CE7. Ability to project ocean platforms and artifacts
MUENO_CE8. Knowledge of the elements of physical oceanography (waves, currents, tides, etc.) necessary for the analysis of the behavior of oceanic structures, and of the elements of chemical and biological oceanography that must be taken into account for maritime safety and for the treatment of pollution, and the environmental impact produced by ships and marine devices

Generical:
MUENO_CG1. Ability to solve complex problems and to make responsible decisions based on the scientific and technological knowledge acquired in basic and technological subjects applicable in naval and ocean engineering, and in management methods
MUENO_CG2. Ability to conceive and develop solutions that are technically, economically and environmentally appropriate to the needs of maritime or integral transportation of people and goods, of the use of oceanic resources and of the marine subsoil (fishing, energy, minerals, etc.), adequate use of the marine habitat and means of defense and maritime security)
MUENO_CG3. Ability to project ships and boats of all kinds
MUENO_CG6. Ability to conduct research, development and innovation in naval and ocean products, processes and methods
MUENO_CG14. Ability to analyze, assess and correct the social and environmental impact of technical solutions
MUENO_CG15. Ability to organize and direct multidisciplinary work groups in a multilingual environment, and to generate reports for the transmission of knowledge and results

Transversal:
CT3. TEAMWORK: Ability to work as a member of an interdisciplinary team, either as a member or performing management tasks, with the aim of contributing to projects pragmatically and sense of responsibility, assuming commitments considering the resources available.
CT4. EFFECTIVE USE OF INFORMATION RESOURCES: Manage the acquisition, structuring, analysis and visualization of data and information in the field of specialty, and critically evaluate the results of this management.
CT5. THIRD LANGUAGE Learning a third language, preferably English, with adequate oral and written and in line with the future needs of the graduates.

Basic:
CB6. Possess knowledge and understanding that provide a basis or opportunity be original in the development and / or application of ideas, often in a research context.
CB7. That the students can apply their knowledge and ability to solve problems in new or unfamiliar environments within broader (or multidisciplinary) contexts related to their study area.
CB8. Students should be able to integrate knowledge and handle the complexity of making judgments based on information that, being incomplete or limited, includes reflections on the responsibilities social and ethical linked to the application of their knowledge and judgments.
CB9. That students can communicate their conclusions and the knowledge and Latest rationale underpinning to specialists and non Specialty clearly and unambiguously.
CB10. Students must possess the learning skills that enable them continue studying in a way that will be largely self-directed or autonomous.

TEACHING METHODOLOGY

Activities will be carried out so that the students know how to apply their knowledge in a professional way. They will demonstrate that they have the necessary skills through the elaboration or defense of arguments and problem solving within the naval and ocean sector. Capabilities to acquire:
1. Being responsible for self-learning, capable to learn independently and continuously.
2. Demonstrate a solid mathematical basis through developments and simplifications.
3. Obtain a working methodology to address and solve hydrodynamic problems.
4. Work in an organized manner, optimizing resources and time, with the aim of meeting delivery deadlines.
5. Acquire habits and skills to work responsibly in a team.
6. Develop critical capacities for the analisis of results.
7. Incorporate new tools to process data and present obtained results.
8. To be fluent in oral and written communication, as well as in the elaboration and structure of reports.

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.
2. Demonstrate knowledge about the theories and concepts on which the hydrodynamics area 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 hydrodynamics, and to develop collaborative skills.

STUDY LOAD

Type	Hours	Percentage
Hours large group	45,0	36.00
Self study	80,0	64.00

Total learning time: 125 h

CONTENTS

Topic 0. Fluid mechanics review

Description:
Review of basic concepts in fluid mechanics.
Navier-Stokes flow governing equations and simplifications.
Introduction to vorticity.
Potential flow governing equations.

Full-or-part-time: 4h
Theory classes: 4h

Topic 1. Introduction to the concept of turbulence

Description:
Flow regimes, specifically turbulence, from a phenomenological point of view.
Vorticity, the origin of chaos, and effect of viscosity.
Formulation of the Reynolds equations and the closure problem.
Approach of some turbulence models.

Full-or-part-time: 18h
Theory classes: 7h
Self study : 11h

Topic 2. Flow around bodies

Description:
Analysis of the problems of external flows, hydrodynamic forces.
Concepts of velocity profile and boundary layer, analysis of the phenomena using Reynolds number.
Analysis of the influence parameters and boundary layer equations for flat plates.
Wall law and analytical equations for internal sublayers.
Boundary layer theory and potential flow.
Effect of pressure gradient and boundary layer dettachment.
Effect of the free surface on the flow around bodies.
Components of advance resistance in ships.

Full-or-part-time: 22h
Theory classes: 8h
Self study : 14h

Topic 3. Experimental methods in naval and ocean engineering

Description:
Basic concepts related to dimensional analysis.
Types of facilities and most relevant test channels.
Most common hydrodynamic tests in naval and offshore engineering.
Methodology, instrumentation and parameters to be evaluated in the different tests.

Related activities:
Realization of some practices in the ETSIN-UPM channel:
- Still water towing test.
- Propeller in open waters test.
- Self-propulsion test.

Full-or-part-time: 23h
Theory classes: 3h
Laboratory classes: 6h
Self study : 14h

Topic 4. Introduction to numerical methods in naval and offshore engineering

Description:
Methods of numerical analysis (or CFD for Computational Fluid Dynamics).
Types of physical models and numerical approaches.
Numerical techniques for solving differential equations.
Free surface modeling techniques.
Problem definition: temporal discretization, boundary conditions, selection of the turbulence model and wall law.
Spatial discretization and different types of meshing.
CFD codes most used in the naval and ocean sector.
Selection of the most appropriate numerical method depending on the type of hydrodynamic problem to be analysed.

Related activities:
Practices with Tdyn CFD program:
- Study of the flow around a simple body in 2D.
- Analysis of the turbulence around a ship hull.
- Simulation of a towing test with free surface.

Full-or-part-time: 41h
Theory classes: 5h
Practical classes: 10h
Guided activities: 5h
Self study : 21h

Tema 5. Hydro-mechanics of propellers

Description:
Concepts and theory of fluid mechanics related to naval propulsion.
Basic theory of fluid mechanics applied to lifting profiles.
Basic principles of the impulsion theory.
Main aspects of cavitation and hull-propeller interaction.

Related activities:
Examples with panel methods Xfoil and Openprop.

Full-or-part-time: 17h
Theory classes: 5h
Guided activities: 2h
Self study : 10h

GRADING SYSTEM

The final mark is the sum of the following partial marks:
Nfinal = 0.3·Nex + 0.3·Npe + 0.4·Npc

Nfinal: Final mark
Nex: Exams marks
Npe: Mark of the practices in model basin
Npc: Mark of fluid simulation practices

EXAMINATION RULES.

Activities rules:

Theory classes
In these classes, the theoretical concepts on the main topics of fluid mechanics will be developed. The main objective is to deal with those concepts related to the field of hydrodynamics within the naval and ocean engineering field.

Practices
Throughout the course different practices, experimental and numerical. The experimental practices will take place in the ETSIN facilities in Madrid. Students unable to attend, should notify in advance and carry out a complementary activity. Reports must be submitted in the given deadline. Any work not delivered or delivered out of time will be marked as 0.

Directed Activities
Part of the practical work will be presented as directed activities. In class, the process and methodology necessaries to solve certain questions will be indicated. Later, students must develop and analyze them.

Tutorials
Tutorials in order to solve doubts can be carried out both in person and in virtual format. Availability will be previously agreed through email. Information about the hours of the teacher's visit and office will be provided at the beginning of the course.

Exams
There will be a final exam that will cover the theory learned during the course. It will be classified as not presented to the student who does not attend any of the exams called.

BIBLIOGRAPHY

Basic:
- White, Frank M. Mecánica de fluidos. 6a ed. Madrid: McGraw-Hill, 2008. ISBN 9788448166038.
- Pope, S. B. Turbulent flows. Cambridge: Cambridge University Press, 2000. ISBN 0521598869.
- Wilcox, David C. Turbulence modeling for CFD. 3rd ed. La Cañada, Califòrnia: DCW Industries, 2006. ISBN 9781928729082.
- White, Frank M. Viscous fluid flow. New York: McGraw-Hill, 2006. ISBN 007124493X.

Complementary:
- Schlichting, Hermann; Gersten, Klaus. Boundary-layer theory [on line]. 9th ed.. Berlin: Springer, 2017 [Consultation: 30/05/2022]. Available on: https://link-springer-com.recursos.biblioteca.upc.edu/book/10.1007/978-3-662-52919-5. ISBN 9783662529195.