SHAKE THE FUTURE.

CENTRALE NANTES

ENGINEERING PROGRAMME

SPECIALISATION

OCEAN: HYDRODYNAMICS AND MARINE ENGINEERING

AUTUMN SEMESTER

Établissement public sous tutelle du
ministère de l'Enseignement supérieur, de la Recherche et de l'Innovation

GROUPE **CENTRALE**

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SEAKEEPING AND STABILITY

OCEAN: HYDRODYNAMICS AND MARINE ENGINEERING, ENGINEERING PROGRAMME SPECIALISATION

AUTUMN SEMESTER

Professor: Pierre FERRANT

Objectives

This course is divided into two parts:

The first part deals with the behavior of marine structures in waves as a part of the linearized theory of fluid-structure interactions using deterministic approaches. Frequency and time approaches are discussed. Moreover, the fundamental relationships between these solutions are systematically underlined. The effects of the second order low and high frequency are also covered. An application is provided based on a solver (frequency domain, linearized free surface conditions and body location) commonly used in engineering.

In the second part which addresses ship stability, general ship aspects are presented and intact and damaged stability are investigated. Computer lab work is completed using state of the art industry software.

Course contents

Part 1 - Seakeeping

1 Objectives, theoretical framework

2 Short review of linear systems theory

3 Formulation of the boundary value problem. Linearization

4 Frequency domain approach
   - a) Definition of diffraction and radiation sub-problems
   - b) Hydrodynamic loads: added mass and damping
   - c) Calculation of motions
   - d) Relations between elementary solutions

5 Time domain approach
   - a) Forced motion of a floating body
   - b) Formulation of the diffraction problem in the time domain
   - c) Equations of motion
   - d) Relation to frequency domain response

6 Second order effects
   - a) Drift forces
   - b) Low and high frequency loading in irregular waves

7 Introduction to nonlinear models
   - a) Nonlinear hydrostatics and Froude-Krylov loading

b) Weak scattered hypothesis
c) Fully nonlinear models

Part 2 - Ship stability

- properties and equilibrium of a floating body
- motions of the floating body
- specific problems of stability
- transversal angles
- regulation calculations of stability

Lab work is proposed using state of the art industry software to solve ship stability.

Course material

J.N. Newman (1977) Marine Hydrodynamics, MIT Press.

O.M. Faltinsen (1990) Sea Loads on Ships and Offshore Structures, Cambridge University Press.

1991, Statique des corps flottants, cours ENSM

R. Servières, 1992, Théorie du navire, ENSTA

R. Hervieu, 1985, Statique du navire, éditions Masson, Paris,

Résolution A.749: code on intact stability for all types of ship covered by IMO instruments

Chapters II-1 of SOLAS: convention internationale de 1974 sur la sauvegarde de la vie humaine en mer, à jour des amendements en vigueur)

Keywords

seakeeping; potential flow model; frequency and time domain; diffraction-radiation; second order effects; stability for intact and damaged ships

Links with other programmes

Marine Environment and Hydrodynamic Loads
Numerical Hydrodynamics: Part 1
Numerical Hydrodynamics: Part 2

LANGUAGE	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT
French	3	20 hrs	4 hrs	6 hrs	2 hrs

NUMERICAL HYDRODYNAMICS: PART 1

OCEAN: HYDRODYNAMICS AND MARINE ENGINEERING, ENGINEERING PROGRAMME SPECIALISATION
AUTUMN SEMESTER

Professor: Lionel GENTAZ

Objectives

The first part deals with numerical panel methods (or BEM for Boundary Element Methods) based on potential flow model. Flows generated by singularities and integral equations are first introduced; then Fredholm equations are obtained and discretized. These methods are applied in the case of ship resistance problems. Lab work covers the implementation of a panel method in a basic case and use of ship resistance solvers based on potential flow model.

The second part looks at the introduction of finite difference schemes to discretize and solve partial derivative problems. In application, a laminar boundary flow on a flat plate is implemented by students.

Course contents

Part 1
Panel methods:

- potential flow model
- elementary singularities: source, sink, dipole, vortex
- continuous distribution of singularities
- integral equations
- Fredholm equation
- discretisation and numerical solution: panel method
- how to take influence of free surface into account?

Ship resistance:

- Froude hypothesis; decomposition of the total ship drag
- numerical treatment using panel method
- examples of results given by panel methods: advantages and limitations

Part 2 - Finite difference schemes:

- definition of finite difference schemes
- definition of consistency, stability, convergence
- influence of schemes (centered or non-centered) on stability
- generalisation to discretization of Navier-Stokes equations

Course material

V. Bertram, Practical Ship Hydrodynamics, 2000

G. Delhommeau, les problèmes de diffraction-radiation et de résistance de vagues: étude théorique et résolution numérique par la méthode des singularités, 1987

Keywords

potential flow, panel methods, integral equations, ship resistance, finite difference schemes

Links with other programmes

Introduction to hydrodynamics
Experimental hydrodynamics
Seakeeping and moorings of marine structures
Numerical Hydrodynamics: Part 2

LANGUAGE	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT
French	**3**	**8 hrs**	**4 hrs**	**10 hrs**	**10 hrs**

Introduction to hydrodynamics

Ocean: Hydrodynamics and Marine Engineering, Engineering programme specialisation

Autumn Semester

Professor: Isabelle CALMET

Objectives

This introduction provides a refresher on fluid mechanics and presents modelling elements which will be useful throughout the specialisation.

Course contents

- Conference on hydrodynamics issues which are relevant today for industry or research
- Introduction to numerical simulation
- Classes of flow modelling in hydrodynamics: Navier-Stokes equations, Euler equations, potential flow models; which flow approximations can be used for fundamental problems like ship resistance, seakeeping, manoeuvrability, impacts, lifting bodies etc
- Introduction to boundary layer and turbulence: physical and modelling aspects.

Course material

Keywords

hydrodynamics in industry and research, flow modelling, Navier-Stokes equations, potential flow equations, boundary layer, turbulence

Links with other programmes

All courses of the Ocean: Hydrodynamics and Marine Engineering Specialisation.

LANGUAGE	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT
French	3	26 hrs	4 hrs	0 hrs	0 hrs

MARINE ENVIRONMENT AND HYDRODYNAMIC LOADS

OCEAN: HYDRODYNAMICS AND MARINE ENGINEERING, ENGINEERING PROGRAMME SPECIALISATION
AUTUMN SEMESTER

Professor: Guillaume DUCROZET

Objectives

This course presents classical models used to model surface waves, with specific attention paid to hypothesis and limits of each of the models for hydrodynamic and ocean engineering. The extension to real sea states is presented with an introduction to hindcast models. The response (movement, loading etc) of marine structures to these wave fields is also studied. Finally, the analysis of extreme waves and/or extreme responses is introduced.

Course contents

1) Introduction

2) Gravity waves

- General equations
- Multiple scales
- Dispersive waves
  - Linear (Airy Wave)
  - Non-linar models (Stokes, stream function, etc)
  - Refraction of gravity waves
  - Diffraction-refraction (Mild-Slope equation)
- Non-dispersive waves (shallow water)
  - Boussinesq equations
  - Solitary wave
  - KdV equation; cnoidal wave

3) Statistical models

- Irregular wave fields modeling
- Usual wave spectra
- Generation and propagation of sea states on a large scale

4) Loadings and response

- Loadings on small bodies
- Response of large bodies to real sea states

Course material

Water wave mechanics for engineers and scientists, Robert G. Dean & Robert A. Dalrymple, Advanced Series on Ocean Engineering (vol.2)

Water waves and ship hydrodynamics: an introduction, A.J. Hermans

Theory and application of ocean surface waves, C.C. Mei, M. Stiassnie & D.K.P. Yue, Advanced Series on Ocean Engineering (vol.23). Part I: Linear aspects; Part II: Non-linear aspects

Keywords

Swell, Water waves, Gravity waves, Airy wave, Stokes wave, nonlinearities, Wave spectrum, Loadings, Morison formula, response spectrum, extreme waves

Links with other programmes

Seakeeping and moorings of marine structures
Numerical Hydrodynamics: Part 1
Experimental Hydrodynamics

LANGUAGE	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT
French	**3**	**16 hrs**	**4 hrs**	**6 hrs**	**4 hrs**

Ship manoeuvrability and moorings

Ocean: Hydrodynamics and Marine Engineering, Engineering programme specialisation

Autumn Semester

Professor: Félicien BONNEFOY

Objectives

This course is divided into two parts.
The first part deals with manoeuvrability modelling and applications.
The second part covers the main characteristics of moorings used in the offshore area.
Practical application with the use of an industrial code is proposed.

Course contents

With regard to manoeuvrability, the basic formulation is presented in a modular approach. Experimental and numerical techniques for hydrodynamic model design are given.

With regard to moorings, the necessity of moorings in marine engineering is highlighted.
The main characteristics of moorings are presented with their associated benefits and drawbacks.
State of the art industry software is used for an offshore floating structure with moorings submitted to waves and currents so that motions of the structure, loads in moorings etc can be evaluated and analysed.

Course material

E.M. Lewandowski, 2004, The dynamics of marine crafts: manoeuvring and seakeeping, Advanced series on ocean engineering, Vol. 22, World Scientific

V. Bertram, 2000, Practical Ship Hydrodynamics, Butterworth Heinemann

T.I. Fossen, 2011, Handbook of marine craft hydrodynamics and motion control, Wiley

Keywords

manoeuvrability - moorings - modelling of physical problems

Links with other programmes

Seakeeping and Moorings of Marine Structures
Experimental Hydrodynamics

LANGUAGE	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT
French	3	16 hrs	6 hrs	10 hrs	0 hrs

Numerical hydrodynamics: part 2

Ocean: Hydrodynamics and Marine Engineering, Engineering programme specialisation
Autumn Semester

Professor: Lionel GENTAZ

Objectives

This course covers the numerical simulation of viscous flow by the usual numerical schemes (finite difference or finite volume).

During lab work a Navier-Stokes solver used in industry is used by students for academic cases: cavity-driven, lid-driven cavity problem; Poiseuille flow; turbulent flow over periodic hills; water column collapse; flow around a ship.

Course contents

- turbulence modelling (Reynolds Averaged Navier-Stokes Equations, Large Eddy Simulation, Direct Numerical Simulation)
- velocity-pressure coupling
- free surface modelling (free surface tracking or free surface capturing procedures) are presented.

Course material

J.H. Ferziger, M. Peric, Computational Methods for Fluid Dynamics, Springer

Keywords

turbulence modelling, Reynolds Averaged Navier-Stokes Equations, velocity-pressure coupling, free surface modelling

Links with other programmes

Introduction to hydrodynamics
Numerical hydrodynamics part 1
Marine Fluid-Structure Interactions
Advanced hydrodynamics

LANGUAGE	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT
French	3	12 hrs	0 hrs	9 hrs	9 hrs

PROJECT: PART 1

OCEAN: HYDRODYNAMICS AND MARINE ENGINEERING, ENGINEERING PROGRAMME SPECIALISATION
AUTUMN SEMESTER

Professor: Lionel GENTAZ

Objectives

This course is the first part of the 80 hour project conducted across the two semesters.
The purpose is to use skills acquired during the Ocean specialisation for practical projects proposed and supervised by Centrale Nantes professors and researchers by or engineers from companies.
Students work in teams of 2 to 3 during this project.

Course contents

Students select their subject in October.
Teams of students work on their subject until January during sessions which are planned in the specialisation's timetable.
A presentation of their work is planned at the end of January.

Course material

All work proposed in the different courses of the specialisation.

Keywords

project; team work; hydrodynamics

Links with other programmes

All courses of the specialisation

LANGUAGE	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT
French	1	0 hrs	0 hrs	0 hrs	32 hrs

EXPERIMENTAL HYDRODYNAMICS

OCEAN: HYDRODYNAMICS AND MARINE ENGINEERING, ENGINEERING PROGRAMME SPECIALISATION
AUTUMN SEMESTER

Professor: Lionel GENTAZ

Objectives

This course presents state-of-the-art experimental techniques for naval and offshore hydrodynamics. Experiments in wave and towing tanks, available at ECN are used as examples.
Ship resistance, self-propulsion tests, manoeuvrability, environmental condition generation (wave, current and wind) are typical topics addressed during the course.

Course contents

Basic signal processing is undertaken in computer lab work.
Five experimental lab sessions are proposed to students:

- ship resistance with the towing tank
- seakeeping in finite depth (small wave tank)
- seakeeping in deep water
- ship stability
- turbulence in jets

Course material

B. Molin, 2002, Hydrodynamique des structures offshore, Editions Technip
S.A. Hughes, 1995, Physical models and laboratory techniques in coastal engineering, Advanced series on ocean engineering, Vol. 7

Keywords

experimental facilities, hydrodynamics, wave tank, towing tank

Links with other programmes

Seakeeping and moorings of marine structures
Ship stability and manoeuvrability

LANGUAGE	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT
French	3	10 hrs	2 hrs	20 hrs	0 hrs

LIFTING BODIES & PROPULSION

OCEAN: HYDRODYNAMICS AND MARINE ENGINEERING, ENGINEERING PROGRAMME SPECIALISATION
AUTUMN SEMESTER

Professor: Antoine DUCOIN

Objectives

The objective of this course is to provide the fundamentals on methods and physics in order to predict hydrodynamic performance and help in the design of lifting bodies. A large range of methods will be presented based on both potential and viscous flows, and some applications will be covered.

The propulsion class will be helpful to define the main characteristics of propellers, to study the performance, sizing and their applications.

Course contents

Lifting profile:

Lecture 1- Introduction: Geometrical parameters, physical parameters, similarity parameters, classicifation of flows
Lecture 2 - Flow and performance analysis
Lectures 3/4 - Potential methods: thin profile theory and lifting line theory
Lecture 5 - Cavitation for lifting profiles

Tutorial: application of the thin profile theory

Lab work: application of the lifting line theory using Matlab - study of viscous and thickness effects using Xfoil

Course material

Keywords

lifting profiles, lifting line method, lifting surface method, aktuator disk method, ship propeller, performance of propeller, design of propeller

Links with other programmes

Numerical Hydrodynamics: Part 1
Marine Fluid-Structure Interactions

LANGUAGE	ECTS CREDITS	LECTURES	TUTORIALS	LABO	PROJECT
French	**3**	**16 hrs**	**6 hrs**	**4 hrs**	**4 hrs**