Title: *Wave-structure interactions and moorings*
Credit value: *5 ECTS*
Mandatory/Optional: *Optional*
Semester: *3*
Lecturers: *Pierre Ferrant, Vincent Leroy, Juan Gomez*
University: *Ecole Centrale Nantes*
Department: *Fluid Mechanics and Thermodynamics*
Rationale: *The first part of this course is devoted to the interactions between ocean waves and marine structures.* *The linearized theory for wave-structure interactions, which is the basis of the state of the art software used in the industry, is described in detail. In addition, different levels of approximation for the nonlinear problem are described, and the influence of second and higher-order nonlinear effects is explained and illustrated.* *The second part addresses the modelling of mooring systems, a key step in the design of ships and marine structures.*
Objectives: *The objective of the first part is to give a complete presentation of the available models for the determination of marine structures' response in a seaway, emphasizing the advantages and drawbacks of each approach.* *A complete presentation of the linearized theory of wave-body interactions, treated in a deterministic sense, is first given. Both frequency domain and time domain approaches are described. Fundamental relations between both solutions are systematically emphasized. High and low-frequency second-order effects are explained and illustrated.* *Then, an overview of the available nonlinear theories and numerical models for wave-structure interactions is given. Different levels of approximation are described, from the simple addition of nonlinear hydrostatics to fully nonlinear time-domain models.* *The second part addresses the modelling of mooring systems. Different options in terms of mooring systems and arrangements are presented to give students the main information necessary for undertaking a mooring design process.* *For both parts lectures and seminars are completed by practical exercises based on the state of the art software for wave-structure interaction and mooring modelling.*

Skills:

Subject skills	REM+ Master Skills						
	L2.1	**L2.2**	**L2.3**	**L2.4**	**L2.5**	**L2.6**	**L2.7**
L3.1. Explain and demonstrate knowledge and understanding of the physical assumptions leading to the potential flow model for wave-structure interactions	X					X	
L3.2. Explain the assumptions justifying the linearization of the wave-structure interaction problem	X					X	
L3.3. Explain and demonstrate knowledge and understanding of the frequency domain response of marine structures in waves	X	X	X	X		X	X
L3.4. Explain and demonstrate knowledge and understanding of the time domain response of marine structures in waves, and its relationship to frequency domain response	X	X	X			X	
L3.5. Explain and demonstrate knowledge and understanding of the main qualitative influence of nonlinear effects on the response of the structure	X					X	
L.3.6. Explain knowledge and understanding of the main problems and technological solutions relative to moorings	X						X
L.3.7. Use a software dedicated to moorings for simple cases	X						
L.3.8. Acquire new skills, organize information and conduct effective reports						X	

Teaching and learning methods:

The course is based on lectures for the theoretical part, completed with illustrative examples and seminars. In addition, computer exercises using state of the art software are organized, and the group is divided into small teams of students.

Allocation of student time:

	Attendance (classroom, lab,…)	**Non-attendance (lecture preparation, self-study…)**
Lectures	18 hours	41 hours
Tutorials	2 hours	12 hours
Lab (computer)	10 hours	42 hours

Assessment:

The assessment is based both on a final individual written exam, and the evaluation of reports on computer exercises.

Assessment Matrix:

Subject skills	Exam	Report
L3.1.	100%	0%
L3.2.	50%	50%
L3.3.	50%	50%
L3.4.	100%	0%
L3.5.	50%	50%
L3.6	0%	100%
L3.7	0%	100%
L3.8	0%	100%

Programme:

Lesson 1	***Objectives, theoretical framework*** *1h theory*
Lesson 2	***Short review of linear systems theory*** *1h theory*
Lesson 3	***Formulation of the boundary value problem. Linearization*** *2h theory*
Lesson 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* *4h theory + 2h tutorial + 4h practical classroom*
Lesson 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* *2h theory*
Lesson 6	***Second-order effects*** *a) Drift forces* *b) Low and high-frequency loading in irregular waves* *2h theory*
Lesson 7	***Introduction to nonlinear models*** *a) Nonlinear hydrostatics and Froude-Krylov loading* *b) Weak scattered hypothesis* *c) Fully nonlinear models* *2h theory*
Lesson 8	***Moorings for marine structure*** *a) Some examples in Oil and Gas energy* *b) Different types of mooring systems* *c) Offloading operations* *d) Some examples in Marine Renewable energy* *e) Mooring main functions* *f) Mooring arrangement*

	g) *Mooring components* h) *Environmental conditions* i) *Mooring Design basis* *4h theory + 6h computer lab*

Resources:

Lectures require a blackboard and projector in the lecture hall.
Lab works are carried out in the computer room.

Bibliography:

- J.N. Newman (1977) *Marine Hydrodynamics*, MIT Press.
- O.M. Faltinsen (1990) *Sea Loads on Ships and Offshore Structures*, Cambridge University Press.
- Adrian Biran (2003) *Ship Hydrostatics and Stability*, Butterworth-Heinemann.
- API recommended Practice 2SK (2005) *Design and analysis of Stationkeeping Systems for Floating Structures*.
- Vryhof anchors (2010) *Anchor Manual, The Guide to Anchoring*.

Further comments: