REM master basic syllabus

Title:
WWSSM Water waves and sea states modelling

Credit value:
4 ECTS

Mandatory/Optional:
Optional

Semester:
3

Lecturers:
Guillaume Ducrozet, Félicien Bonnefoy

University:
Ecole Centrale Nantes

Department:
Fluid Mechanics and Thermodynamics

Rationale:
This course intends to describe the main source of loading for structures at sea (e.g. marine renewable energy systems), namely ocean waves. This is essential for the design of such structures and is the starting point of all hydrodynamics' studies (see courses: wave-structure interactions, experimental hydrodynamics, marine renewable energy, etc.).

Objectives:
First we give an overview of some of the numerous mathematical models used to represent free surface gravity waves, and the associated underlying flow. The scope is voluntarily restricted to the most useful models generally used by naval engineers and researchers. In a few cases, a deeper theoretical insight is presented in order to allow the students to understand the subtleties of water wave theory.
In the second part, the use of the statistical approach is presented, both for the representation of sea states and for the sea structure's response.

Skills: *(according to the list of skills provided)*

Subject skills	REM Master Skills						
	L2.1	**L2.2**	**L2.3**	**L2.4**	**L2.5**	**L2.6**	**L2.7**
L3.1. Explain the purpose of Hydrodynamics modeling in Marine and Ocean Engineering today	X						X
L3.2. Explain and demonstrate knowledge and understanding of the main mathematical models to describe Free Surface flows	X					X	
L3.3. Determine and Explain which mathematical model is adapted for which problem of Hydrodynamics	X	X		X		X	
L.3.4. Explain and demonstrate knowledge and understanding of the main aspects of numerical simulation in Hydrodynamics	X					X	
L3.5. Explain main aspects of the stability for floating structures							
L.3.6. Use a software dedicated to stability for simple cases	X		X	X		X	
L3.7. Acquire new skills, organize information						X	

Teaching and learning methods:

The course is based on lectures for the theoretical part. These are divided into two main parts as described in the program.

In addition to those master classes, classroom tutorials and computer practices will be organized. The latter will be done in small groups of students.

Signal processing basics are introduced in a dedicated computer lab work involving MATLAB software.

Allocation of student time:

	Attendance (classroom, lab…)	**Non attendance (lecture preparation, self study…)**
Lectures	14 hours	28 hours
Tutorials	4 hours	14 hours
Lab. (computer)	14 hours	26 hours

Assessment:

The assessment of this course is based on a final written exam that covers the whole range of knowledge taught in the lectures. In addition, the computer lab work will lead to the writing of a report that will be evaluated.

Assessment Matrix:

Subject skills	**Assessment method**	
	Exam	**Report**
L3.1.	100%	0%
L3.2.	100%	0%
L3.3.	100%	0%
L.3.4.	100%	0%
L.3.5.	50%	50%
L.3.6.	0%	100%
L.3.7.	0%	100%

Programme:

Lesson 1	***Introduction to marine environment*** *Description of the ocean and the different kind of waves existing. Focus on the gravity waves and the processes responsible for their generation.* *2h theory*
Lesson 2	***Gravity waves modelling*** *Derivation of the governing non-linear equations and introduction of the multiple scale method to generate particular subset of equations* *2h theory*
Lesson 3	***Dispersive waves*** a) Airy Potential; derivation of the solution by separation of variables. Expression of all the related physical quantities: group velocity, energy density, energy flux, limits of the linear model. b) Higher order Stokes solutions (3rd order, 5th order). Sequential construction of the Stokes higher order solutions. Specific nonlinear features of Stokes waves. c) From deep to shallow water i) Refraction and shoaling of dispersive waves ii) Shallow-water (non-dispersive) waves

	4h theory + 2h practical classroom + 4h computer
Lesson 4	***Statistical models for wave field description*** a) Random sea state modeling. b) Usual wave spectra models. c) Wave generation. *4h theory + 2h practical classroom + 6h computer*
Lesson 5	***Random responses of structures at sea*** a) Random responses of a linear system. b) Review of the results for ship responses by a deterministic theory. c) Motions on a real sea state. d) Extreme responses, design factors. *2h theory + 4h computer*

<u>Resources:</u>

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

<u>Bibliography:</u>

- Robert G. Dean & Robert A. Dalrymple, *Water wave mechanics for engineers and scientists*, Advanced Series on Ocean Engineering (vol.2).
- A.J. Hermans, *Water waves and ship hydrodynamics: an introduction.*
- C.C. Mei, M. Stiassnie & D.K.P. Yue, *Theory and application of ocean surface waves*, Advanced Series on Ocean Engineering (vol.23). *Part I: Linear aspects ; Part II: Non-linear aspects*

<u>Further comments:</u>