FULL EXAM, SHIP DYNAMICS / MEC-E2004

Key topics: Ship Dynamics for Design, Sea Surface description and Equations of Motion, Seakeeping methods, Wave Loads, Seakeeping Criteria and model tests, Added Resistance, Maneuvering

Time: 30.05.2022, 11:00-14:00 hrs., Virtual exam, Open book

Answers in English only. Clear writing and use of the right terminology is required. Answers should be provided below each question. At the end of the exam save your file as **surname_student number.pdf** and email it to [redacted]

1. Ship Dynamics for Design – general principles

a. What are the key areas of the subject of ship dynamics in terms of design, i.e. why is it needed? **2p**

b. Why are full scale measurements and model tests needed in ship dynamics? Give three practical examples **1 p**

c. What is the difference between seaworthiness and seakeeping? **1p**

d. What are the main categories of wave loads and which methods are used to model them ? **1p**

2. Waves

a. What are the roles of wave spectrum and scatter diagram in terms of calculating ship motions and loads? Give an example on how you can find the worst conditions for your ship when you know the Response Amplitude Operator (RAO)? **2p**

b. What is the basic difference between the ISSC and ITTC spectrum (*brief explanation*) ? **0.5p**

c. The ISSC wave spectrum is defined as:

$$S_w(\omega) = 0.11\left(\frac{2\pi}{T_z}\right)^4 \frac{H_{1/3}^2}{\omega^5} e^{-\frac{0.44}{\omega^4}\left(\frac{2\pi}{T_z}\right)^4}$$

For $T_Z = 7s$ and $H_{1/3} = 2.6$m the RAO of the bending moment of the ship is given by frequency and a corresponding RAO vector [ton^2/m^2]:

$$w_{RAO} = \{\ 0.3 \quad 0.4 \quad 0.5 \quad 0.6 \quad 0.7\ \},$$

$$RAO = \{\ 0 \quad 4\times10^9 \quad 2\times10^9 \quad 3\times10^9 \quad 0\ \}$$

Calculate the response spectrum. **1p**

d. Define what is a freak wave? Why a freak wave cannot be calculated with a standard wave spectrum and scatter diagram? **1.5p**

3. Controlling Ship Dynamics (Added Resistance and Maneuvering)

a. Explain physically how we can achieve hull motion reduction. Explain the positive and negative features of 4 different systems that may be used for motion reduction. **2p**

b. Explain the physics (sequence of events) on how the rudder of a single propeller ship produces the turning moment? When the ship turns what other motion components become active apart from yaw? **2p**

c. What motion component(s) mainly cause the added resistance of the ship? **1p** What are the requirements that make the ship motion stable? Define Controllability and Motion Stability. **1p**

4. Seakeeping and wave loads

a. Name and sketch the rigid body ship equations of motion in waves. Explain the physical meaning of Newton's 2^{nd} law of motion with application to ship dynamics. Write down this combined equation of motion and name each of the terms. **1p**

b. What is the difference between Quasi Static Response, Dynamic Response and Resonance response. **2p**

c. Which are the two key methods used for linear seakeeping analysis? Discuss the principles of these key methods. **1p**

d. Write Newton's Equation of motion for hydroelasticity. Summarize in tabular format the basic 2D and 3D linear hydroelastic modelling methods for global load assessment. **1p**

5. Bonus Question

a. The problem of linear ship motions in waves is approached by considering 3 types of forces in addition to the restoring forces of hydrostatic origin. What are they used for? Name them and define them **2p**

b. Draw the typical patterns of Heave and Pitch RAOs for a typical symmetric section. What is defined as wave matching region and what would be the influence of wave matching region on pitch response (*explain physically by drawing the RAO at different L/lamda ratios in way of the wave region*)? **2p**

c. What test is presented in enclosed figure? What causes the lateral displacement? **2p**