REVISION QUESTIONS   Ship Dynamics

1. **Seakeeping methods – general principles**
   a. Which are the two key methods used for linear seakeeping analysis? Discuss the principles of these key methods. **1.5p**
   b. What are the basic assumptions of the perfectly linear seakeeping problem? **1.5p**
   c. Discuss in terms of advantages and limitations what are the differences between linear and nonlinear theories? When the use of nonlinear theories for seakeeping calculations would be preferable? **2p**

2. Wave loads (global and local)

a. Name the basic classes of local and global wave loads. Highlight the role of hydroelasticity **1p**

b. Define hogging and sagging. Discuss the role of the loading instruments and hull condition monitoring systems. **1p**

c. 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**

d. Discuss the basic principles and physical meaning of the $1/20^{th}$ and L/lamda Rules **2p.**

3. Seakeeping criteria

a. What is motion sickness? Explain three measures of ship performance in terms of seakeeping criteria. **2p**

b. Why seakeeping tests are carried out? Briefly describe typical model test set ups and considerations for (a) free seakeeping models (b) horizontally restricted seakeeping models (c) hydroelastic models **2p**

c. What is the relevance of seakeeping in terms of shipping operations? **1p**

4. Added Resistance and Maneuvering

a. What motion component(s) mainly cause the added resistance of the ship? **1p**

b. Name two ways we can typically use to assess ship resistance in waves. What are the advantages and limitations of these methods? **2p**

c. What are the requirements that make the ship motion stable? Define Controllability and Motion Stability. **2p**

5. Ship motions

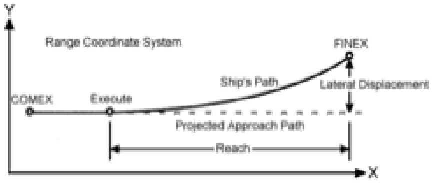
a. The problem of linear ship motions in waves is approached by considering 3 types of forces in addition to the restoring forces of hydrostatic origin. What are they used for? Name them and define them **(1p)**

b. Name the six degrees of freedom representing the motions of a ship in waves. Define added mass and damping. Draw the roll, heave and sway RAO of added mass and damping for a typical box like ship section **(2p)**

c. 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)**

6. Advanced seakeeping topics

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



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

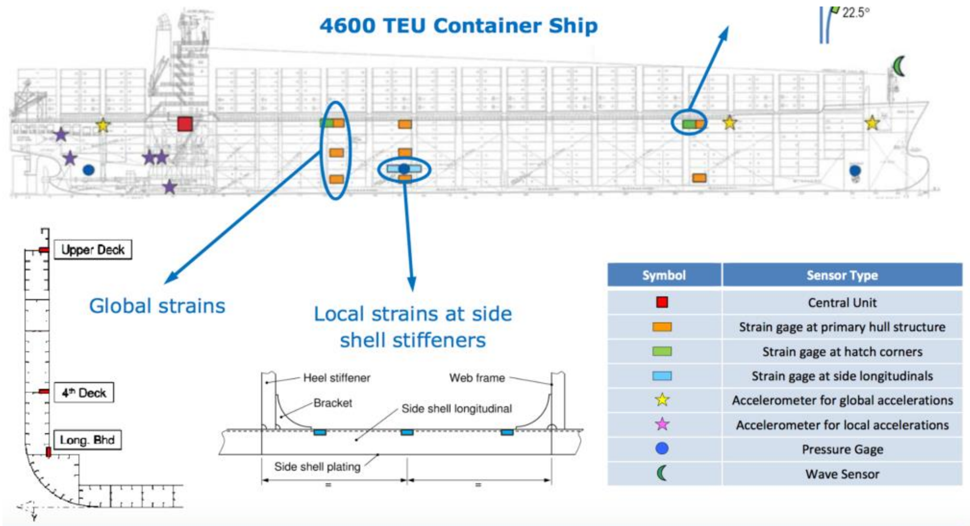
c. How are operational effectiveness and voluntary speed loss connected by definition? **1p**

7. 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. If you have 4 uni-axial and 1 tri-axial accelerometer to measure ship motions how would you position those to get all 6 degrees of freedom of the ship accurately measured? Sketch these on the figure given below. Use commonly used notations/terms to describe rigid hull motions. **2p**

c. Would there be any difference between the sagging and hogging bending moments and why? Which IACS URS requirement defines this envelope of loads? Use sketches. **1p**



8. Waves

e. 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**

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

g. 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 [ton²/m²]:

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

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

Calculate the response spectrum. **1p**

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

9. Controlling Ship Dynamics (Added Resistance and Maneuvering)

d. 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**

e. 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**

f. 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**

10. Seakeeping

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

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

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

11. Wave loads

a. Name the basic classes of local and global wave loads **1p**

b. Define hogging and sagging. Discuss the role of the loading instruments and hull condition monitoring systems. **2p**

c. 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**

d. Discuss the basic principles and physical meaning of the $1/20^{th}$ and L/lamda Rules **1p.**

12. Bonus Question

d. 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**

e. Name the six degrees of freedom representing the motions of a ship in waves. Define added mass and damping. Draw the roll, heave and sway RAO of added mass and damping for a typical box like ship section **1p**

f. 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**

13. General Ship Dynamics and Ocean Waves

a. What are the key areas of the subject of ship dynamics in terms of design and operational monitoring, i.e. why is it needed? **1.5 p**

b. Why are full scale measurements and model tests needed in ship dynamics? Give three practical examples **0.5p**

c. How waves can be classified in terms of their generation mechanism, regularity and intensity. **1p**

d. What is the basic difference between the ISSC and ITTC spectrum? **0.5p**

e. 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. 1.0p

f. Define a freak wave. How a freak wave may be generated and how are freak waves accounted for in ship design development ? **0.5p**

14. Controlling Ship Dynamics

a. Why are we interested to achieve hull motion reduction? Give practical examples with application in ship design and operations. **1p**

b. Explain the positive and negative features of 4 different systems that may be used for motion reduction. **1p**

c. 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? **1p**

d. Compare: (a) constant and controllable pitch propeller characteristics and their adequacy (b) the use of podded propulsion versus a traditional propeller solution. For each (a) and (b) present your results on a table with advantages and limitations. **2p**

15. Short Term Ship Response

a. Why ship short-term response is evaluated from 0.5 to 3 hours and long-term response over 20 - 25 years? Give physical / design related and mathematical reasoning. **2p**

b. Explain / sketch the wave formation mechanisms of wind-generated waves. What do we mean when we say that the sea state is fully developed? **1p**

c. Explain the energy content of waves. How can you estimate the total energy using linear wave theory? **1p**

d. Explain the basic difference between linear wave (Airy Wave) and nonlinear wave (Stokes Wave) theories **1p**

16. Equations of motion

a. Name and sketch the ship rigid body degrees of freedom. **0.5p**

b. What is the difference between Quasi Static Response, Dynamic Response and Resonance response. Explain the physical backgrounds. **1.5p**

c. What is damping and how can we physically assess damping? Name 3 cases corresponding to damping induced response for a 1 dof system. Sketch the displacement versus time dynamic response curve for a 1 dof system for which $\zeta < 1.0$. **3p**

17. Cross-cutting Question

a. When ship dynamics are accounted for, the encounter frequency with the waves is used instead of the absolute wave frequency. Why is this the case ? **2p**

b. Explain why the most significant degrees of freedom are those that have a restoring force associated with them. Give a practical example of this principle with reference to heave motion **1p**

c. Define regular and irregular waves (include sketches and basic mathematical symbols in your explanation). **0.5p**

d. Define the mean wave elevation, variance, mean deviation for an irregular wave **0.5p**

e. Explain the basic mathematical principle of Fast Fourier Transform and the procedure we should follow to translate results from the frequency to the time domain and vice versa **1p.**