Faculty of Maritime Engineering and Marine Sciences

Ship Dynamics

Quiz 3: Uncoupled roll and random response **August 17th, 2021**

Student: ..... ID: .....

Useful formulas:

Virtual radius of gyration: $\left(\frac{k_{xx''}}{B}\right)^2 = f\left[C_B C_u + 1.10 C_u (1 - C_B)\left(\frac{H_e}{T} - 2.20\right) + \frac{{H_e}^2}{B^2}\right]$

Fourier transform: $F^*(\omega) \equiv \frac{1}{2\pi}\int_{-\infty}^{\infty} dt f(t) e^{-i\omega t}$

Autocorrelation function: $R(\tau) \equiv \lim_{T\to\infty} \frac{1}{T}\int_{-T/2}^{T/2} dt \varsigma(t)\varsigma(t+\tau)$

Rayleigh probability density distribution: $p_{\tilde{\varsigma}}(z) = \frac{z}{\sigma^2} e^{-\left(\frac{z^2}{2\sigma^2}\right)}, z > 0$

Normal probability density distribution: $p_{\varsigma}(z) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(z-\mu)^2}{2\sigma^2}}$

Wave excitation moment in roll: $M_o = -i\rho g \varsigma_o k sen\beta \left[\int_{-L/2}^{L/2} \frac{2}{3} b^3 e^{ikx\cos\beta} dx\right] e^{i[-\omega_e t]}$

Closed books

1. Explain why the International Maritime Organization in the new ship intact stability criteria consider as one of the modes of capsizing the dead ship condition? (10)

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2. A small fishing vessel operating in the Galápagos islands has the following main characteristics: (L: 20 m, B: 5 m, D: 2.5 m, T: 1.5 m, C_B=0.60, C_P: 0.70, GM: 0.30 m). The nondimensional damping coefficient ξ is 0.08. Calculate the corresponding value of the damping roll coefficient, assuming that the virtual radius of gyration is 35% of the beam. (10)

34409 kg m^2/sec	44409 N m sec	54409 N m sec	64409 kg m^2/sec

3.- In Ikeda's formulation to approximate the roll damping coefficient it is decomposed in five components, which are listed below. For each one of the components, mention is less than 4 words a characteristic of each component. (10)

Frictional, B_F	
Wave, B_W	
Eddy, B_E	
Lift, B_L	
Bilge keel, B_{BK}	

4.- For the simplified ship model available in our SiMar lab you are asked to estimate the amplitude of the excitation moment from regular waves at the condition of resonance. Main characteristics of the model are: L: 45 cm, B: 25 cm, D: 12 cm, W: 67.67 N. Consider a 1 cm wave amplitude. (10)

0.103 N	5.104 kg m/sec^2	-i 10.04 N	51.04 N

5.- The grade point average GPA of the 243 Naval engineering students registered in the I semester 2022 have been analyzed, and it is concluded that its distribution follows the normal probability distribution. To be an academic assistant a student should have a good GPA. How many students do you expect to have a grade point average between 7.5 and 8.0, and be able to apply for this type of assistantship? After some years of experience, the following values may be applied: mean: 7.404 and st. deviation: 0.608. (10)

15 students	10 students	41 students	68 students

6.- If you were analyzing a time register of the vertical acceleration of a planing boat traveling between islands in the Galápagos, you would need its spectral density function, PDF. What would be the units of that resulting PD function? (5)

(m/sec)/sec	m/sec^3	(m/sec)^2/sec	m^2/sec^4

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Part 2

Closed books

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Rayleigh probability density distribution: $p_{\tilde{\varsigma}}(z) = \frac{z}{\sigma^2} e^{-\left(\frac{z^2}{2\sigma^2}\right)}, z > 0$

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I declare that during this exam I have fulfilled the Code of Ethics of our university.

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Problem 1. In annex 3 of the Intact Stability code of the IMO, there are recommendations to determine the metacentric height GM by means of rolling period tests (for ships up to 70 m in length). They present the following formula for that:

$$GM = \left(\frac{f\,B}{T}\right)^2$$

where B is the ship's beam in metres and T is the time for a full rolling period in seconds.

From the dynamic equilibrium differential equation for uncoupled roll of a ship, deduce the value of the constant f, using typical values considered in class. Use the International System of units. (20)

2.- The simplified version of the spectral density function, SDF, for the roll motion of a ship model is shown in the attached figure. What is the possibility that the crest of any oscillation be larger than 12º?
(25)