College of Maritime Engineering and Sea Sciences

Ship Dynamics

2nd evaluation: Roll and irregular response **Feb. 1st, 2019**

Student: ....

5 points each question

1.- Consider a regular wave train moving in the horizontal direction: $\varsigma = \varsigma_o e^{i(kx' - \omega_o t)}$, where *x'* is the position in a coordinate system fixed on earth, and, *k* and ω_o are the number and frequency of the waves. If you want to express surface elevation with respect to a coordinate system which is moving with a ship, traveling with velocity *U* and at an angle β with respect to the waves, you would use:

a. $\varsigma = \varsigma_o e^{i[k((Ut+x)\cos\beta + ysen\beta) - \omega_o t]}$	b. $\varsigma = \varsigma_o e^{i[k((Ut+x)\cos\beta - ysen\beta) - \omega_o t]}$
c. $\varsigma = \varsigma_o e^{i[k((Ut+x)\cos\beta - ysen\beta) + \omega_o t]}$	d. $\varsigma = \varsigma_o e^{i[k((Ut-x)\cos\beta - ysen\beta) - \omega_o t]}$

2.- A train of regular waves is approaching a ship from the beam, and in a simplified manner the moment of roll excitation per unit length may be estimated as: $dM_o = \frac{2}{3}\rho g b^3 \left[- iksen\beta \varsigma_o e^{i[k(x\cos\beta) - \omega_e t]}\right] dx$, where *b* is half beam along the ship, *k* and ς_o are number and amplitude of incident waves, β is angle of ship relative to wave motion. For a box-barge the moment of roll excitation, when the ship receives waves from the beam:

a. $M_o = -\rho g k \varsigma_o L B^3 / 12$	b. $M_o = -i\rho g k \varsigma_o L B^3 / 12$
c. $M_o = -i\rho k \varsigma_o L B^3 / 12$	d. $M_o = -i\rho g k \varsigma_o L^3 B / 12$

3.- According to Himeno's method, the component of roll damping that is mostly influenced by ship velocity is:

a. Lift	b. Waves	c. Friction	d. Bilge keels

4.- Which one of the following relationships is correct. $R(\tau)$ is the Autocorrelation function, $S^{+}(\omega)$ is the spectral density function, *w* is a random variable which varies with time, *t*, and *T* is a very long period of time. The symbol $\Im[\ ]$ represents Fourier transform.

a. $\frac{1}{T}\int_{-T/2}^{T/2} dt\ w(t)\ w(t+\tau)=\int_{0}^{\infty} d\omega\ S^{+}(\omega)\ e^{i\omega\tau}$	b. $R(\tau)=\int_{0}^{\infty} d\omega\ S^{+}(\omega)\ e^{-i\omega\tau}$
c. $S^{+}(\omega)=\int_{0}^{\infty} dt\ R(t)\ e^{i\omega t}$	d. $S^{+}(\omega)=\Im^{-1}\left[R(\tau)\right]$

5.- Considering units, which one is the correct formulation for the spectral density of sea state, according to Pierson-Moskowitz, with the International system of units?

a. $S^{+}(\omega)=\frac{8.1x10^{-3}}{\omega^{4}}g^{3}\ e^{-0.74(g/(V\omega))^{4}}$, SI	b. $S^{+}(\omega)=\frac{8.1x10^{-3}}{\omega^{4}}g^{2}\ e^{-0.74(g/(V\omega))^{4}}$, SI
c. $S^{+}(\omega)=\frac{8.1x10^{-3}}{\omega^{4}}g\ e^{-0.74(g/(V\omega))^{4}}$, SI	d. $S^{+}(\omega)=\frac{8.1x10^{-3}}{\omega^{5}}g^{2}\ e^{-0.74(g/(V\omega))^{4}}$, SI

6.- The harmonic motion of a buoy in the vertical direction is: $\theta(t) = 45e^{i(\omega t - 30^o)}$, in degrees. What is its mean square value, when the frequency ω is π rad/sec?

a. $\overline{\theta^2} = \pi^2 / 32$	b. $\overline{\theta^2} = \pi / 32$	c. $\overline{\theta^2} = \pi^2 / 16$	d. $\overline{\theta^2} = \pi^2 / 2$

7.- Consider that the surface elevation z in the wave tank of the Naval Eng. Lab is a random variable with Normal probability distribution (assuming zero meano): $p_\varsigma(z) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{z^2}{2\sigma^2}}$, with $\sigma = \pi$ in cm. In an experiment suppose you are registering the surface elevation with scan rate of s_r,[scan/sec], what is the number of values M_j, of that you would expect in the interval $\varsigma_j - \Delta\varsigma / 2 < z < \varsigma_j + \Delta\varsigma / 2$, in cm, during a time period of T seconds?

a. $M_j = T\,\sigma\, s_r\; p(\varsigma_j)$	b. $M_j = T\,\Delta\varsigma\; p(\varsigma_j)$	c. $M_j = T\,\Delta\varsigma\, s_r\; p(\varsigma_j)$	d. $M_j = T\,\sigma\; p(\varsigma_j) / sr$

8.- Which of the expressions is the correct one, where $\overline{\omega}_c$ is the average frequency between crests, $\overline{\omega}_z$ is the average frequency of up-crossing points, m_n are the moments of order n, and, ε is the narrowness parameter of the spectral density function.

a. $\overline{\omega}_c = \sqrt{\frac{m_4}{m_2}}$	b. $\overline{\omega}_c = \sqrt{\frac{m_2}{m_4}}$	c. $\overline{\omega}_z = \sqrt{\frac{m_o}{m_2}}$	d. $\varepsilon = \sqrt{1 - \frac{m_2}{m_o m_4}}$

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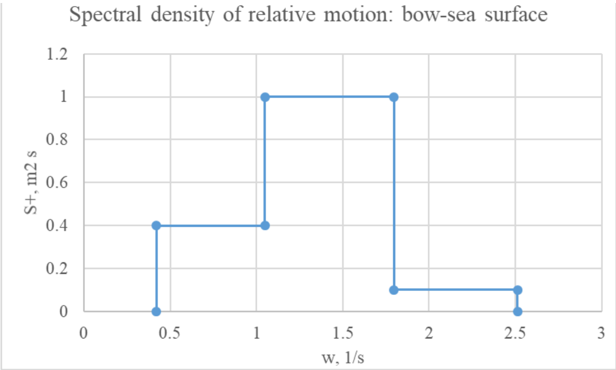
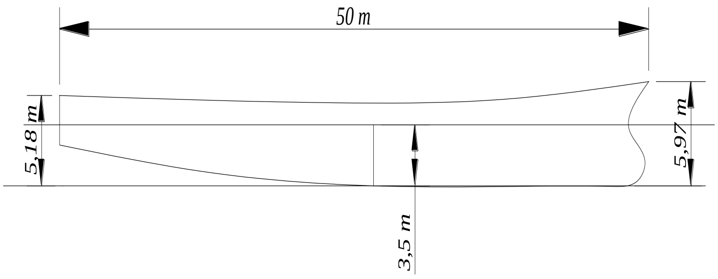
1.- In the appendix of the Intact stability criterion for passenger and cargo ships of the International Maritime Organization, IMO, there is method to approximate GM_T for ships with length less than 70 meters, based on the roll balance period of the ship. The formula to estimate metacentric height in meters is:

$$GM_T = \left(\frac{f\,B}{T_r} \right)^2 ,$$

where B is ship's beam, m, and T_r is the roll period of oscillation, sec. If IMO recommends a value for the constant f of 0.78 for a coastal traffic ship, what would be the percentage of the beam that corresponds to the virtual gyration radius of the vessel?
(25 points)

2.- Consider that you have the following spectral density function of the relative vertical motion between a ship and the sea surface elevation, at the bow of the vessel (*L: 50, B: 10, D: 5 m, Δ: 1100 tons, U: 12 knots*). What is the time (in minutes) you would expect before for the first time water reaches the deck of the ship?
(35)





Normal & Rayleigh probab. density fns.: $p_\varsigma(z) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(z-\mu)^2}{2\sigma^2}}$, $p_{\tilde{\varsigma}}(z) = \frac{z}{\sigma^2} e^{-\left(\frac{z^2}{2\sigma^2}\right)}$

Parameters of S.density fn.: $m_n = \int_0^\infty d\omega\, \omega^n\, S^+(\omega_e),\ n = 0, 2, 4, \ldots,\ \omega_c = \sqrt{\frac{m_4}{m_2}},\ \varepsilon = \sqrt{1 - \frac{m_2^2}{m_0 m_4}}$

jrml/2019

I certify that during this examination I have complied with the *Code of Ethics of ESPOL*:

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