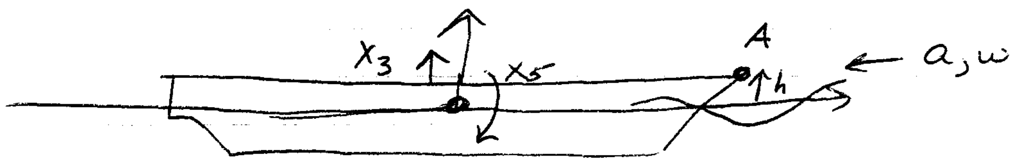
04/29/04

Coupled Motions & Seakeeping : Complex Events

① Water on Deck



Design ⇒ need to choose h so that we have only so much water on deck

Assumptions ⇒ Incident wave is not significantly diffracted @ A

⇒ Ignore steady elevation (equilibrium ship position)

⇒ Assume linear motions

$$\eta(x_1, t) = a e^{i(\omega t + k x_1)}$$

x_1 ⇒ inertial reference ⇒

$$x = x_1 - Ut$$

$$\eta(x, t) = a e^{i(\omega_e t + kx)}$$

where $\omega_e = \omega + kU$

$$\eta(x_A, t) = \hat{\eta}_A e^{i\omega_e t} = a e^{i(\omega_e t + k x_A)}$$

$$\eta(x=0, t) = \hat{\eta}_{⊗} e^{i\omega_e t} = a e^{i\omega_e t}$$

↑ midships

$$\Rightarrow \hat{\eta}_A = \hat{\eta}_{⊗} e^{ikx_A}$$

phase shift

Relative Distance from A to free surface

$$Z_A(t) \simeq \underset{\substack{\uparrow\\ \text{equilibrium}\\ \text{pt}}}{h} - \underset{\text{wave height}}{\eta_A} + \underset{\text{heave}}{X_3} - X_A X_5$$

pitch • distance from center of pitch to pt. A

Let $Z_1(t) = \eta_A - X_3 + X_A X_5$ such that

when $Z_1(t) > h$ then bow is under water (submerged)

$$\hat{Z}_1(\omega) = \hat{\eta}_A - \hat{X}_3 + X_A \hat{X}_5$$

$$\hat{X}_3(\omega) = H_3(\omega_e)\,\hat{\eta}_\phi \qquad \text{heave amplitude}$$

$$\hat{X}_5(\omega) = H_5(\omega_e)\,\hat{\eta}_\phi \qquad \text{pitch amplitude}$$

$$\hat{Z}_1(\omega) = \underbrace{\left\{ e^{ikX_A} - H_3(\omega_e) + X_A H_5(\omega_e) \right\}}\hat{\eta}_\phi$$

$$S_{Z_1}(\omega_e) = \left| H_{Z_1}(\omega_e) \right|^2 \underbrace{S_\eta(\omega_e)}_{\substack{\text{incident waves @}\\ \text{encounter frequencies}}}$$

$$H(\omega_e) = e^{ikx_A} - H_3(\omega_e) + x_A H_5(\omega_e)$$

This is a <u>COMPOSITE EVENT</u>!

The relative phase term is very important

We can use the spectrum for deck elevation, $S_{Z_1}(\omega_e)$, to get Rate that water exceeds level h (on avg.)

$$\therefore \quad \bar{\eta}(h) = \frac{1}{2\pi}\sqrt{\frac{M_2}{M_0}}\, e^{-h^2/2M_0}$$

M_0, M_2, M_4 are moments of spectrum $S_{Z_1}(\omega_e)$