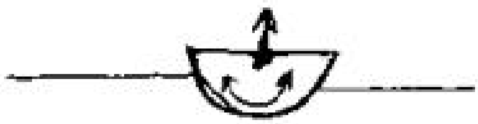
13.42 Notes

12 APR 2005

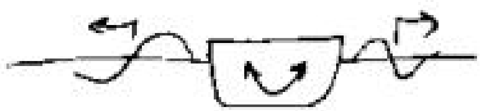
Roll Motion

Coupled with sway & yaw.

Linear damping due to radiated waves is small so Roll Motion can be LARGE.



- perfect circular shape w/ motion about its center
- No waves are created

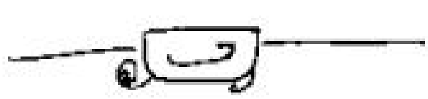


- Non circular shape
- Wave making is relatively small

Where does additional daming come from?

- FRICTION
- Eddy - generation

- Surface friction ⇒ <u>VISCOUS</u>



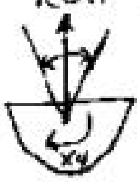
- Eddy - generation

- Separation on appendages such as fins or keels
- Also Eddy - generation

FRICTION $F_F = C_f \frac{1}{2} \rho U^2 S$ ← surface area

$F \sim U^2$ ← NON-LINEAR

Roll Force $\rightarrow$ $F_4 = \phi\, \dot{x}_4 |\dot{x}_4|$ $\quad \phi$ = constant



$x_4 = \phi_0 \cos \omega t$ $\quad \phi_0$ = roll amplitude

CAN WE FIND AN <u>EQUIVALENT LINEARIZATION</u> OF ROLL FORCE?

$$F_4^L = \varepsilon \dot{x}_4$$

Where coefficient ε is determined such that the energy per cycle spent by F_4 is the Same as from the Linearized F_4^L $\rightarrow$

$$\int_0^T F_4 \dot{x}_4 \, dt = \int_0^T F_4^L \dot{x}_4 \, dt$$

↑ integral over one period (cycle)

$$\dot{x}_4 = \phi_0 \omega \sin \omega t$$

$$\phi\, \omega^3 \phi_0^3 \int_0^{2\pi} \sin^2\theta |\sin\theta| \, d\theta = \varepsilon \omega^2 \phi_0^2 \int_0^{2\pi} \sin^2\theta \, d\theta$$

$$\int_0^{2\pi} \sin^2\theta |\sin\theta| \, d\theta = 2\int_0^{\pi} \sin^3\theta \, d\theta = \frac{4}{3} \cdot 2$$

$$\int_0^{2\pi} \sin^2\theta \, d\theta = \frac{2\pi}{2}$$