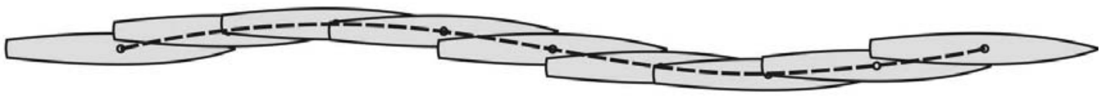
# Test case 3a.8: Pure sway



## Conditions

- Captive pure sway motion in still water
- Pitch, heave, and roll free
- Without rudders
- With bilge keels

*Pre scribed PMM motions*:

- Sway motion: $\eta_{PMM} = -2S_{mm} \sin\left(\frac{2\pi N}{60} t\right)$
- Sway velocity: $v_{PMM} = -2\left(\frac{2\pi N}{60}\right) S_{mm} \cos\left(\frac{2\pi N}{60} t\right)$
- Sway acceleration: $\dot{v}_{PMM} = 2\left(\frac{2\pi N}{60}\right)^2 S_{mm} \sin\left(\frac{2\pi N}{60} t\right)$
- Heading angle: $\psi = 0$
- Yaw rate: $r = 0$
- Yaw acceleration: $\dot{r} = 0$

| $F_n$ [-] | $R_n$ [-] | $U_C$ [m/s] | $N$ [rpm] | $S_{mm}$ [m] | $\beta^*_{\max}$ [deg] | $v'_{\max}$ [-] |
|---|---|---|---|---|---|---|
| 0.280 | $4.643\times10^6$ | **1.531** | **8.0210** | **0.1584** | 10.0 | 0.174 |

$\beta^*_{\max}$ : corresponding maximum drift angle

Items and Remarks

| Figure Number | Items | Remarks |
|---|---|---|
| Fig. 3a.8-1 | Time history of non-dimensionalized longitudinal force ( $X'$ ) | To be compared with experimental results download |
| Fig. 3a.8-2 | Time history of non-dimensionalized transverse force ( $Y'$ ) | To be compared with experimental results download |
| Fig. 3a.8-3 | Time history of non-dimensionalized yaw moment ( $N'$ ) | To be compared with experimental results download |
| Fig. 3a.8-4 | Time history of pitch angle | To be compared with experimental results download |
| Fig. 3a.8-5 | Time history of heave motion | To be compared with experimental results download |
| Fig. 3a.8-6 | Time history of roll motion | To be compared with experimental results download |
| Fig. 3a.8-7 | Damping parts of $Y'$ and $N'$ vs. $v'$ | To be compared with experimental results download |
| Fig. 3a.8-8 | Inertial parts of $Y'$ and $N'$ vs. $\dot{v}'$ | To be compared with experimental results download |

- Coordinate system for comparision is ship-fixed at midship on the undisturbed waterplane.

- $F_n = \dfrac{U_C}{\sqrt{gL_{PP}}}$, $R_n = \dfrac{U_C \cdot L_{PP}}{\nu}$

  where, $U_C$ is towing carriage speed, $g$ is the gravitational acceleration and $\nu$ is the kinematic viscosity of water.

- All quantities are non-dimensionalized with water density ( $\rho$ ), ship speed ( $U = \sqrt{u^2 + v^2}$ ), lateral underwater area ( $A_0 = L_{pp}\, T_m$ ), and the length between perpendiculars ( $L_{pp}$ ).

$$X' = \frac{F_{X_{Hydro}}}{0.5\rho U^2 A_0} = \frac{F_{X_{total}} + M\dot{u}}{0.5\rho U^2 T_m L_{pp}}$$

$$Y' = \frac{\mathrm{F}_{\mathrm{Y}_{\mathrm{Hydro}}}}{0.5\rho \mathrm{U}^2 A_0} = \frac{F_{Y_{total}} + M\dot{v}}{0.5\rho \mathrm{U}^2 T_m L_{pp}}$$

$$N' = \frac{\mathrm{M}_{\mathrm{Z}_{\mathrm{Hydro}}}}{0.5\rho \mathrm{U}^2 A_0 \mathrm{L}_{\mathrm{pp}}} = \frac{M_{Z_{total}} + M(X_G\dot{v} - Y_G\dot{u})}{0.5\rho \mathrm{U}^2 T_m \mathrm{L}_{\mathrm{pp}}^2}$$

- From the Fourier series expansion of $Y'$ and $N'$,

$$Y' = a_o + \sum_{n=1}^{\infty} a_n \cos(n\omega t) + \sum_{n=1}^{\infty} b_n \sin(n\omega t)$$

$$N' = c_o + \sum_{n=1}^{\infty} c_n \cos(n\omega t) + \sum_{n=1}^{\infty} d_n \sin(n\omega t)$$

damping parts are

$$Y'_D = \sum_{n=1}^{3} a_n \cos(n\omega t)$$

$$N'_D = \sum_{n=1}^{3} c_n \cos(n\omega t)$$

and inertial parts are

$$Y'_T = b_1 \sin(\omega t)$$

$$N'_T = d_1 \sin(\omega t)$$

where,

$$\omega = \frac{2\pi N}{60}$$

- Non-dimensional transverse velocity and accelerations:

$$v' = \frac{v}{U_C}$$

$$\dot{v}' = \frac{\dot{v} L_{PP}}{U_C^2}$$