This Mathcad sheet will calculate the longitudinal (surge) force, lateral (sway) force and turning moment (yaw), based on Wang's paper. Below please input the ship particulars as required:

Length of Moored vessel (LBP), in feet:	$L \equiv 658$
Midship cross-sectional area of moored ship, in ft^2:	$A1 \equiv 3936.299$
Length of passing vessel (LBP), in feet:	$L_2 \equiv 902.2$
Midship cross-sectional area of passing ship, in ft^2:	$A2 \equiv 7099.888$
Water density, in slug/ft^3:	$\rho \equiv 1.9905$
Passing ship velocity (incl. current), in knots:	$U \equiv 5$
Separation distance (from centerline to centerline), in feet:	$SEP\_DIST \equiv 221.8$
Stagger distance (negative when passing ship behing moored ship), in feet:	$STA\_DIST \equiv 0$
Water depth, in feet	$D \equiv 47$

$SEP\_DIST = 221.8$

Results:

$SurgeForce = 8.01 \times 10^{-12}$ in lbf

$SwayForce = 4.803 \times 10^{4}$ in lbf

$YawMoment = 2.574 \times 10^{-9}$ in ft-lbf

Sectional area curves as functions of length, for both moored and passing ship (from Wang's paper):

$$S_1(x1) \equiv \left(1 - \frac{4 \cdot x1^2}{L^2}\right) \cdot A1 \qquad dS_1(x1) \equiv \frac{d}{dx1} S_1(x1) \qquad S_2(x2) \equiv \left(1 - \frac{4 \cdot x2^2}{L_2^{\,2}}\right) \cdot A2 \quad dS_2(x2) \equiv \frac{d}{dx2} S_2(x2)$$

$$F(x1, \xi, \eta) \equiv \int_{-\frac{L_2}{2}}^{\frac{L_2}{2}} \frac{dS_2(x2) \cdot (x2 - x1 + \xi)}{\left[(x2 - x1 + \xi)^2 + \eta^2\right]^{\frac{3}{2}}} \, dx2$$

$$G(x1, \xi, \eta) \equiv \int_{-\frac{L_2}{2}}^{\frac{L_2}{2}} \frac{dS_2(x2)}{\left[(x2 - x1 + \xi)^2 + \eta^2\right]^{\frac{3}{2}}} \, dx2$$

$$Wang\_Surge(\xi, \eta) \equiv \frac{\rho \cdot U^2}{2 \cdot \pi} \cdot \int_{-\frac{L}{2}}^{\frac{L}{2}} dS_1(x1) \cdot F(x1, \xi, \eta) \, dx1$$

surge force formulation for infinite depth

$$Wang\_Sway(\xi, \eta) \equiv \frac{\rho \cdot U^2 \cdot \eta}{\pi} \cdot \int_{-\frac{L}{2}}^{\frac{L}{2}} dS_1(x1) \cdot G(x1, \xi, \eta) \, dx1$$

sway force formulation for infinite depth

$$Wang\_Yaw(\xi, \eta) \equiv \frac{\rho \cdot U^2 \cdot \eta}{\pi} \cdot \int_{-\frac{L}{2}}^{\frac{L}{2}} \left[\left(dS_1(x1) \cdot x1 + S_1(x1)\right) \cdot G(x1, \xi, \eta)\right] dx1$$

yaw moment formulation for infinite depth

$$eta(\eta, h, n) \equiv \sqrt{\eta^2 + 4 \cdot n^2 \cdot h^2}$$

separation distance parameter as a function of finite depth

$$\mathrm{Wang\_Surge\_Depth}(\xi,\eta,h) \equiv \sum_{n=-10}^{10} \mathrm{Wang\_Surge}(\xi,\mathrm{eta}(\eta,h,n))$$

surge force as a function of finite depth

$$\mathrm{Wang\_Sway\_Depth}(\xi,\eta,h) \equiv \eta\cdot\sum_{n=-10}^{10} \frac{\mathrm{Wang\_Sway}(\xi,\mathrm{eta}(\eta,h,n))}{\mathrm{eta}(\eta,h,n)}$$

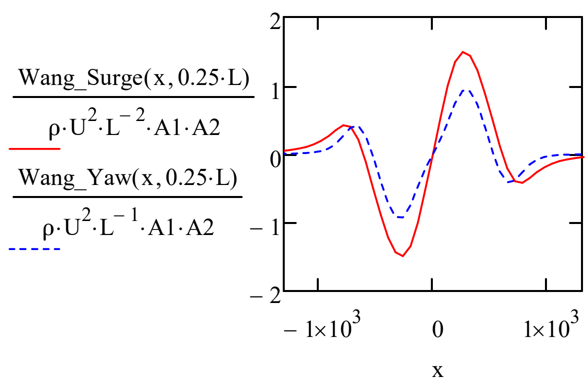
sway force as a function of finite depth

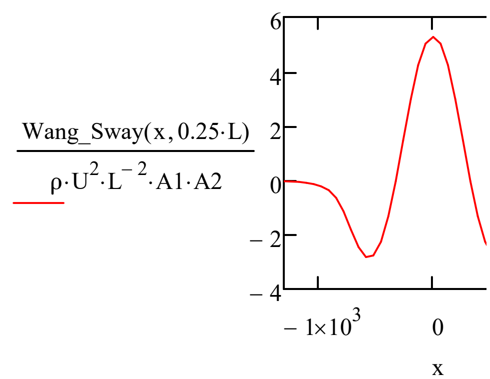
$$\mathrm{Wang\_Yaw\_Depth}(\xi,\eta,h) \equiv \eta\cdot\sum_{n=-10}^{10} \frac{\mathrm{Wang\_Yaw}(\xi,\mathrm{eta}(\eta,h,n))}{\mathrm{eta}(\eta,h,n)}$$

yaw moment as a function of finite depth

Plots of Surge, Sway and Yaw forces and moments for separation distance of 0.25xL for infinite water depth:

$x := -10\cdot L, -9.9\cdot L .. 10\cdot L$





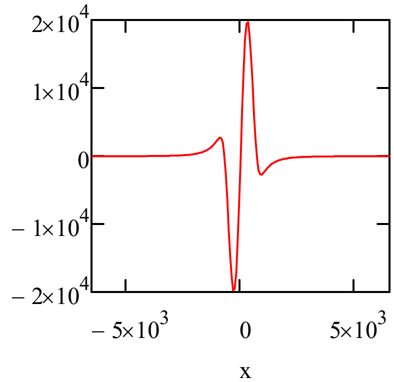
$$\frac{\mathrm{Wang\_Sway}(0, 0.25\cdot L)}{\rho\cdot U^2\cdot L^{-2}\cdot A1\cdot A2} = 5.272$$

$$\mathit{SurgeForce} \equiv \mathrm{Wang\_Surge\_Depth}(\mathrm{STA\_DIST}, \mathrm{SEP\_DIST}, D)$$

$$\mathit{SwayForce} \equiv \mathrm{Wang\_Sway\_Depth}(\mathrm{STA\_DIST}, \mathrm{SEP\_DIST}, D)$$

$$\mathit{YawMoment} \equiv \mathrm{Wang\_Yaw\_Depth}(\mathrm{STA\_DIST}, \mathrm{SEP\_DIST}, D)$$

Wang_Surge_Depth(x, SEP_DIST, D)



Wang_Sway_Depth(x, SI

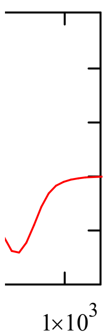
Wang_Surge_Depth(x, SEP_DIST, D) =

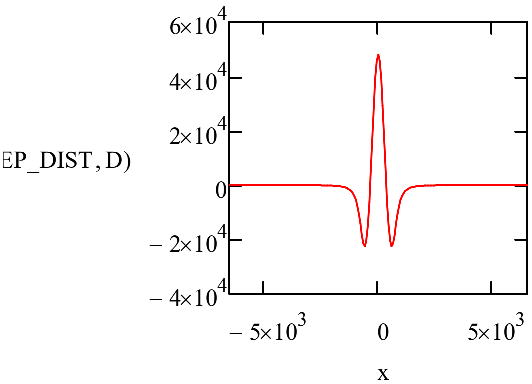
3.814
3.969
4.131
4.301
4.48
4.669
4.867
5.076
5.297
5.529
5.775
6.034
6.308
6.597
6.903
...

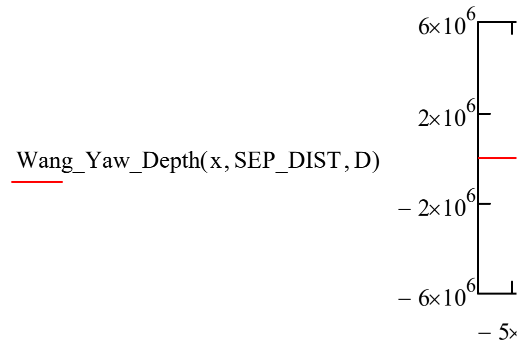
Wang_Sway_De

-0.524
-0.551
-0.579
-0.609
-0.642
-0.676
-0.713
-0.751
-0.793
-0.837
-0.885
-0.935
-0.989
-1.047
-1.109
...

$286.85\text{m} = 941.109\cdot\text{ft}$	moored length
$50\text{m}\cdot 15.85\text{m}\cdot 0.95 = 8103.879\cdot\text{ft}^2$	moored cross section
$286.85\text{m} = 941.109\cdot\text{ft}$	passing length
$50\text{m}\cdot 15.85\text{m}\cdot 0.95 = 8103.879\cdot\text{ft}^2$	passing cross section
$\frac{50\text{m}}{2} + 200\text{ft} + \frac{50\text{m}}{2} = 364.042\cdot\text{ft}$	Sep distance
$16.764\text{m} = 55\cdot\text{ft}$	water depth

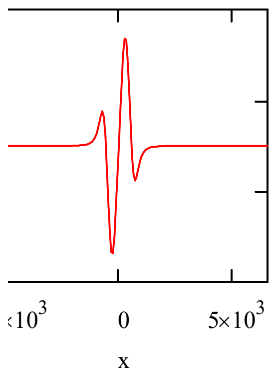

1×10^3





pth(x, SEP_DIST, D) =

Wang_Yaw_Depth(x, SEP_DIST, D)
8.552
9.08
9.647
10.256
10.909
11.612
12.368
13.182
14.059
15.005
16.026
17.128
18.321
19.611
21.008
...



×10^3
0
5×10^3
x