

# **The Study of Ship Motions in Regular Waves using a Mesh-Free Numerical Method**

by

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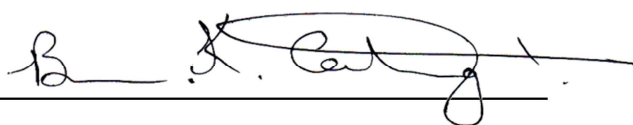
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A handwritten signature in black ink, appearing to read 'Bruce K. Cartwright', is written over a horizontal line.

**Bruce K Cartwright**

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## Abstract

Mesh-free methods are becoming popular in the maritime engineering fields for their ability to handle non-benign fluid flows. Predictions of ship motions made using mesh-free methods need to be validated for benign conditions, such as regular waves, before progressing to non-benign conditions. This thesis aims to validate the response of a ship in regular waves by the Smoothed Particle Hydrodynamics (SPH) mesh-free method.

Specifically, the SPH technique uses a set of interpolation points, designated SPH particles, located at nodes that track the centre of discrete fluid volumes with time. As part of this research a set of simple rules was established to locate the free surface of the fluid based on the location of the SPH particles. These simple rules were then used to validate the hydrostatics of a ship floating in the fluid, identifying the vertical location of the water line to 0.22% of the Design Water Line length.

The propagation of regular waves in SPH has historically been problematic, resulting in diminishing wave height with propagation distance. In this study, non-diminishing deep-water regular waves were generated in a shallow tank by moving segments of the floor in prescribed orbital motions, a technique developed by the researcher and hereinafter called the moving-floor technique. The resulting waves showed no discernible loss in wave height with propagation distance, and were computationally more efficient than modelling a full-depth tank. The resulting surface profiles of the waves were within  $\pm 5\%$  of the theoretical values, while the velocity and pressure profiles were within  $\pm 10\%$ .

The pitch and heave transfer functions for a round bilge high speed displacement hull form at Froude numbers of 0.25 and 0.5 were predicted using waves in SPH developed by the moving-floor technique. These predictions were compared to transfer functions obtained from experiments in a towing tank. The results obtained using SPH generally under-predicted the experimental results by about 10%, but by as much as 50% at peaks or at high frequencies where the responses were small. Reasons for the under-prediction by the SPH technique are discussed in this thesis.

The outcomes of this research demonstrate that with some refinement, the SPH technique should be capable of accurately predicting the motions of a ship in regular waves. It is hoped this work will serve as a stepping stone to exploit the flexibility of the SPH technique to analyse any shape hull, to be applied to non-linear waves, and to be coupled with a structural solver.

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