Inclining experiment on a model ship

Project description, MAS 124
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Introduction

The purpose of this test is to learn how to experimentally determine the vertical position of the centre of gravity, $\overline{KG}$, for a ship. This is important to be able to determine the initial stability $\overline{GM}$ of a vessel. For this purpose, an inclining experiment is performed on a model ship where the model is heeled to small angles (<5 degrees) by moving known weights to known positions transversely on deck. The ship has a simple outline, and its dimensions and lightweight information are given in *Krengelab_ritning.pdf*. A suggestion of how to name each dimension is given on page 2 in the same document. It can be noted that the model has a discontinuous waterline area with respect to the draught T. On page 3-4 in the same document the discontinuity is graphically explained.

Each group of 2 students should work together and write a scientific report, which briefly (maximum 10 pages) describes the calculations and experiment. The measurements and analysis of the inclining test should be presented clearly. Information about report writing will be given during lecture. It is obligatory to use MATLAB for the calculations and presentation of figures.

Before the lab

The experiment will consist of inclining experiments for different draughts. Hence, the student group first has to prepare a MATLAB code that calculates the required ballast that has to be loaded into the model in order to obtain a certain draught. The draught for which each team will do their inclining experiment will first be given during the lab. Assume a fresh water density of 1000 kg/m^3. The experiment will give the value on $\overline{GM}$, and the other properties depending on the shape of the ship can be calculated prior to the lab, i.e $\overline{KM} = \overline{KB} + \overline{BM}$. Both methods for calculating $\overline{KM}$, i.e. the exact analytic and numerical integration method, are accepted. Demonstrate the use of a `for`-loop by creating a MATLAB figure for the $\overline{KM}$ and $\overline{KB}$ curve as done in Øving 1, Oppgave 3b. The discontinuity at the stern should be handled by using an `if-else` statement. When the lab is finished, and $\overline{KG}$ has been determined, add the $\overline{KG}$ curve to the diagram and present the figure in the report. If you finish quickly with the above before the lab, you can continue to prepare your program by using the given made-up inclining experimental results in Table 1 below. Use the MATLAB function `polyfit` to perform a linear fit to the measured data and to obtain the slope for calculating $\overline{GM}$ as presented during lecture and in [1, 2, 3]. You can neglect the weight of the test moment masses when calculating the displacement mass.

During the lab

Two groups work together during the lab. **At least one computer with a working m-file to calculate the necessary ballast for a certain draught needs to be available.** First, the water temperature is measured and the density is retrieved from the recommended procedures by ITTC [4]. Then, the required ballast is calculated to give a certain draught. Depending on how fast the group works, there will be time for more than one inclining experiment, or time to move weights to verify the resulting change in center of gravity with theoretical calculations of center of mass. Table 1 below shows a typical result of what a group measures during a test.
Beware: Make sure that you understand how your measured data is defined and be sure to have enough measurements to make a linear fit to your data. Also, to learn about the accuracy of each measurement, repeat some measurements using the same inclining moment.

Heel moment [kgm]	ϕ [deg]
-0.083	-4.5
-0.0588	-3.2
-0.0588	-3.1
-0.0286	-1.7
-0.0286	-1.6
0	0.03
0	-0.02
0.0286	1.7
0.0286	1.8
0.0588	3.3
0.0588	3.2
0.0831	4.4

Table 1: Made-up test data to prepare with.

After the lab

Update the heel moment and angle data to the values that you have obtained during the lab and evaluate $\overline{KG}$. The report should include at least two MATLAB figures. One where the linear fit to experimental data is presented and another where the $\overline{KM}, \overline{KB}, \overline{KG}$-curves are presented. Do not present the experimental data in a table, a figure is enough. The draught(s) at which the inclining test was performed together with corresponding displacement and calculated values for $\overline{KM}, \overline{KB}, \overline{KG}$ and final $\overline{GM}$ should be clearly presented in a neat table and commented on in the text, are the results logical? The MATLAB code has to include at least the following functions: `if-else`, `for`-loop, `polyfit`. Figures need to be rendered with fontsizes, colours and linestyles in the code (do not use the figure's GUI).

Report and m-file delivery

Each group should provide their MATLAB m-file(s) together with the report in a zipped folder via *Canvas* not later than the date given in Oversikt.pdf. The zipped folder should be named according to your group name (A1...G2). When using own defined functions (waterplane_cals.m for instance), make sure that these are included in the zip-folder. Also, run your main code to check that no errors occur directly before you zip the folder.

References

[1] K. J. Rawson and E. C. Tupper. *Basic ship theory.* Elsevier Butterworth-Heinemann, Jordan Hill, Oxford and Woburn, MA, 5th edition, Volume 1, 2001.

[2] E. C. Tupper. *Introduction to Naval Architecture.* Elsevier Butterworth-Heinemann, Jordan Hill, Oxford, 3rd edition, 1996.

[3] Geir Fuglerud et. al. *Marin Teknikk Intro, Marin teknikk 1.* Marin Teknisk Senter, NTNU, Trondheim, 3rd edition, 2005.

[4] ITTC. Fresh water and seawater properties. (Recommended Procedures, 7.5-02-01-03), 2011.

References available on Canvas