Chapter 3

Dynamic Ballasting Experiment

3.1 Dynamic Ballasting PreLab Assignment

1. Consider the descriptions of dynamic ballasting methods for properly determining the mass distribution in the model.

   (a) For the **Knife Edge Method**, what is the equation for the pitch gyradius? What do T and a refer to? How is a different from a_0? What is θ? (include appropriate units)

   (b) For the **Bifilar Suspension Method**, what is the equation for the pitch gyradius? What do T, x_R, and h refer to (include appropriate units)? How might you ensure that the wires each support half the weight of the model?

2. In the methods for determining the pitch gyradius of a model, moving the mass in what direction (relative to the CG) increases the gyradius? If the gyradius is increased, what happens to the measured period?

3.2 Dynamic Ballasting Experimental Assignment

1. **Purpose**: To introduce you to the procedures used to properly set the pitch and yaw mass moments of inertia for models tested in the USNA Hydromechanics Laboratory. Setting the mass moment of inertia properly is an additional requirement to proper ballasting for models that will be tested in waves. Setting the proper ballast and mass distribution (mass moment of inertia) is called dynamic ballasting.

2. **Procedure**: We will be performing dynamic ballasting on a $1/36^{\text{th}}$ scale model of the DDG-51 class destroyer and a $1/144^{\text{th}}$ scale model of the AOE-6. The principal dimensions of the models, and target displacements, LCGs, and longitudinal gyradius, k_5, are given below. You are to secure ballasting weights in the model so that the desired displacement and gyradius are achieved. The problem facing the test engineer is to arrange the available ballast within the model so as to achieve the desired pitch gyradius, k_5. The principle employed is to treat the ship as a compound pendulum, i.e. a pendulum whose mass is distributed over its length rather than being concentrated as in a simple pendulum. Two experimental methods are commonly used to accomplish this task. Both involve timing the period of oscillation of the model (compound pendulum) in air. You will use the Bifilar Suspension Method to set the proper pitch gyradius for the DDG-51 model and the Knife Edge Method to set the proper pitch gyradius for the AOE-6 model.

	DDG-51 Model Data	**AOE-6 Model Data**
L_{PP}	12.945 ft	60.85 inches
Beam	1.645 ft	8.92 inches
Draft	0.584 ft	3.19 inches
Displacement	402.25 lbs	35.48 lbs
LCG	0.75 inches aft of midships	32.41 inches aft of bow tip
k_5	25% L_{PP}	25% L_{PP}

3. **Data Collection**: For the knife edge method you will record the distance a_0 and the angle θ. For the bifilar suspension method you will record the length of the support wires, h, and the distance between the support wires, $2x_R$. For each method you will record the total ballast added to the model and the location of the ballast relative to the LCG or midships. The position of the ballast should be recorded for each oscillation run. For each mass distribution condition, you will record the total time, the number of oscillations, and the resulting oscillation period.

4. **Data Analysis**: The data plots and tables you must create are

   - A table of the measured information for the knife edge and bifilar suspension methods (a_0, θ, h, and $2x_R$).
   - A table (possibly including pictures or drawings for explanation) detailing the mass distribution (total mass and placement of mass) for each swing and labeling each condition sensibly.

- A table of measured time, number of oscillations, and resulting oscillation period for each mass distribution.
- A table with oscillation period, pitch gyradius, and pitch gyradius as a percentage of L_{PP} for each mass distribution.
- Clearly identify the dynamic ballasting (mass amount and placement) that produced the correct (or best) pitch gyradius (k_5).

5. **Written Assignment**: Complete an individual Reflection paper on the dynamic ballasting laboratory. In your reflection, consider the following:

   (a) Why is it important to dynamically ballast a model for a seakeeping test but not for a resistance test? What is the difference in ballasting requirements for the two types of testing?

   (b) Why is it called "dynamic" ballasting?

   (c) If you had to ballast your capstone model for a seakeeping test, which method (knife edge or bifilar suspension) would you use? Explain your reasoning.

   (d) Consider a model with a very small allowance for additional ballast (after accounting for model weight, instrumentation, etc.). Identify at least two challenges in properly setting the model for an accurate seakeeping experiment.