Extracted from
"THE THEORY AND PRACTICE OF MECHANICAL ENGINEERING LABORATORY"
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# Buoyancy, Hydrostatic Forces, and Stability of Floating Bodies

## ASPECTS TO DEVELOP AND DISCUSS IN THE ENGINEERING LAB REPORT

### PART A. BUOYANCY

1. Tabulate and organize the experimental data obtained for this part. Make sure to include the measured temperatures of the water, proper nomenclature of the measured parameters and the original units used during the measurements. Use explanatory diagrams to clearly identify the experimental parameters.

2. For each case, determine the buoyant force using Archimedes' Principle, i.e.: the magnitude of the buoyant force is equal to the weight of fluid displaced by a submerged or floating body. Present one sample calculation that shows the procedure to obtain the buoyant force using this principle.

3. Now, for each case determine the experimental buoyant force using the parameters directly measured with the mass balance. Refer to this buoyant force as the experimental buoyant force. Tabulate these forces together with the buoyant force obtained via the Archimedes' Principle. Compare the values for each case. Provide this comparison in percent basis. Do the experimental results confirm Archimedes' Principle? Discuss.

3. Plot the Experimental Buoyant Force versus the height indicated by the scale. What type of trend is observed? Is the trend linear, polynomial, exponential? Explain.

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### PART B. HYDROSTATIC FORCES ON A SUBMERGED PLANE AREA

1. Tabulate and organize the experimental data obtained for this part. Develop separate tables for each angle of inclination experimented on the unit. Also, indicate in the tables whether the plane area was partially submerged or totally submerged.

Use explanatory diagrams to identify the experimental parameters and their symbols. Photographs are preferable.

2. Now, for the case when the plane surface is vertical, use the procedure explained in the lecture, and evaluate the resulting hydrostatic force $\mathbf{F_R}$ and the location of the center of pressure $\mathbf{R_P}$ **WITH RESPECT TO** the axis of rotation of the quadrant tank (**Important Note**: the procedure studied in the lecture provides the location of the center of pressure with respect to a point "S", which is the intersection of the direction line of the plane and the surface of the liquid. Therefore, the appropriate modification must be made in order to determine the center of pressure with respect to the axis of rotation of the quadrant tank.)

3. Complete similar evaluations for each case investigated during the experiment, i.e.: for the different instances of liquid level where the plane surface was observed to be **partially**, and **totally** submerged. Tabulate every parameter calculated during the step-by-step procedure explained in the lecture.

4. For each case also calculate the moment $\mathbf{M_R}$ of the resulting hydrostatic force $\mathbf{F_R}$ with respect to the axis of rotation of the quadrant tank. Organize these values in a separate table. These values will be compared to the counter-moment used to maintain the equilibrium of the quadrant tank.

5. Calculate the counter-moment $\mathbf{M_m}$ exerted by the balancing masses with respect to the axis of rotation and organize these values together with the moments of the hydrostatic forces calculated in step 4.

6. Plot the moment $\mathbf{M_R}$ of the resulting hydrostatic force $F_R$ as a function of the counter-moment $\mathbf{M_m}$. produced by the balancing masses. Discuss the nature of the plot. Does the plot reflect the expected result? Why? Why not? Discuss.

7. **Repeat steps 1 through 6 for the case where the quadrant tank is rotated a selected angle with respect to the vertical direction.**

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## PART C. STUDY OF THE STABILITY OF A FLOATING BODY

1. Tabulate and organize the experimental data obtained for this part. Use suitable nomenclature and explanatory diagrams to identify the experimental parameters collected.

2. For each case investigated, use the procedure explained by your instructor in order to identify the location of the metacenter. To this effect, first plot the horizontal displacement of the disk to the left and right from the sail centerline as a function of the angle of tilt. Next, fit the plot to a straight line and determine the slope. Use this slope in the equation explained by the instructor and determine the distance between the metacenter and the center of gravity.

3. Now, determine the distance between the metacenter and the center of buoyancy MB by adding the distance between the center of buoyancy and the center of gravity to the distance determined in step 2. This is the experimentally obtained distance MB. Complete this procedure for each case investigated, and present one sample calculation showing the mathematical steps followed to obtain the results.

4. Tabulate your results clearly for each case investigated. In the same table, show the percent difference between the experimental distance MB and the theoretically calculated distance MB.

5. Examine the variation of the metacenter location with respect to the bottom of the float. Based on your experimental results, what would be the distance at which the weight (circular disk) should be placed so that the float become unstable? Use a diagram to illustrate your answer and explain.

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