MECHANICS / Buoyancy

ARCHIMEDES’ PRINCIPLE

OBJECTIVE
Determining buoyant updraught as a function of immersion depth.

SUMMARY
Archimedes’ principle states that a body immersed in a fluid experiences an upward force (updraught or force of buoyancy) \( F_G \). The magnitude of this force is equal to the weight of the displaced fluid. For a regularly shaped immersed body, the updraught is proportional to the depth \( h \) to which the body is immersed as long as this is smaller than the height \( H \) of the body itself.

BASIC PRINCIPLES
Archimedes’ principle states that a body immersed in a fluid experiences an upward force (updraught or force of buoyancy) \( F_G \). The magnitude of this force is equal to the weight of the displaced fluid.

For a regularly shaped immersed body with a surface area \( A \) and height \( H \), immersed to a depth \( h \), the following applies:

\[
\begin{align*}
F_G &= \rho \cdot g \cdot A \cdot h, \text{ where } h < H \\
F_G &= \rho \cdot g \cdot A \cdot H, \text{ where } h > H
\end{align*}
\]

This experiment uses a block of weight \( F_0 \). This weight acts on a dynamometer at the same time as the block is immersed in water to a depth \( h \), so that the total force present is given by the following:

\[
F_M = F_0 - F_G(h)
\]

EVALUATION
The values measured for the updraught \( F_G \) as a function of the relative immersion depth \( h/H \) all lie on a straight line through the origin with the following gradient:

\[
\alpha = \rho \cdot g \cdot A \cdot H
\]

The density of water can be calculated from this gradient.

EXPERIMENT PROCEDURE
• Measure the force on a body immersed in water.
• Determine the updraught and confirm that it is proportional to the depth to which the body is immersed.
• Determine the density of water.

REQUIRED APPARATUS

<table>
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<tr>
<th>Quantity</th>
<th>Description</th>
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<tbody>
<tr>
<td>1</td>
<td>Immersion Block Al 100 cm³</td>
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<td>1</td>
<td>Precision Dynamometer 5 N</td>
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<td>1</td>
<td>Callipers, 150 mm</td>
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<td>1</td>
<td>Set of 10 Beakers, Tall Form</td>
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<td>1</td>
<td>Laboratory Jack II</td>
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<td>Stainless Steel Rod 750 mm</td>
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<tr>
<td>1</td>
<td>Clamp with Hook</td>
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</table>

Fig. 1: Updraught \( F_G \) as a function of relative immersion depth \( h/H \)

Fig. 2: Schematic representation