Archimedes' principle

DETERMINING BUOYANT UPDRAUGHT AS A FUNCTION OF IMMERSION DEPTH

- 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.

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GENERAL 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:

$F_G = \rho \cdot g \cdot A \cdot h$, for $h < H$ (1a)

and

$F_G = \rho \cdot g \cdot A \cdot H$, for $h > H$ (1b)

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:

$F(h) = F_0 - F_G(h)$ (2)

Fig. 1 Determining the updraught on a block.

LIST OF EQUIPMENT

1	Immersion block, Al, 100cm³	1002953 (U15037)
1	Precision dynamometer, 5N	1003106 (U20034)
1	Callipers, 150 mm	1002601 (U10071)
1	Beaker, tall	1002873 (U14211)
1	Laboratory jack II	1002941 (U15020)
1	Tripod stand, 150 mm	1002835 (U13270)
1	Stand rod, 12 mm x 750 mm	1002935 (U15003)
1	Clamp with hook	1002828 (U13252)

SET-UP AND PROCEDURE

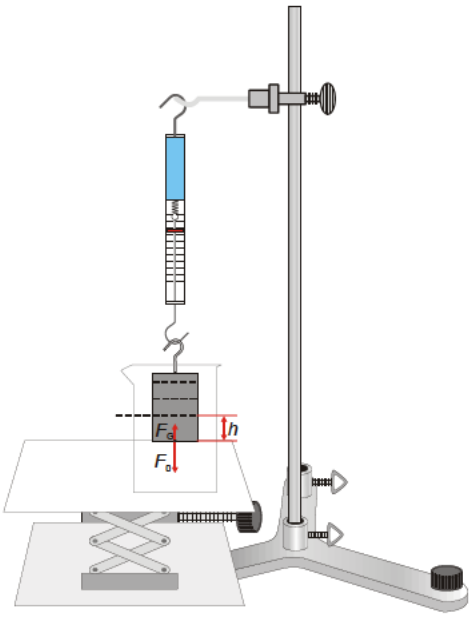

Fig. 2 Set-up for determining updraught

- Measure the dimensions of the block to be immersed and make a note of them.
- Mark the block with a pen at 25%, 50% and 75% of its full height.
- Hold the precision dynamometer facing vertically downwards and adjust its zero point.
- Measure the weight F_0 of the immersion block with the dynamometer and make a note of it.
- Fill the beaker with 400 ml of water and set up the experiment as shown in Fig. 2.
- Use the laboratory jack to lift up the beaker till the block is immersed in water up to the 25% mark.
- Measure the force F and write it down.
- Raise the beaker again till the other marks are reached and repeat the experiment for each of them.

SAMPLE MEASUREMENT AND EVALUATION

Immersion block:

Height: 62.5 mm, width: 40 mm, weight: F_0 = 2.7 N

Table 1: Force F on immersion block as well as the updraught F_G as a function of the immersion depth h

h / H	F / N	F_G / N
0%	2.70	0.00
25%	2.45	0.25
50%	2.20	0.50
75%	1.95	0.75
100%	1.70	1.00

- Use the force measured F to determine the updraught F_G and enter the values into the table.
- Plot the updraught F_G as a function of the relative immersion depth h/H in a graph and draw a straight line through the points starting from the origin.
- Calculate the density of water from the slope of the graph and compare it with values quoted in literature.

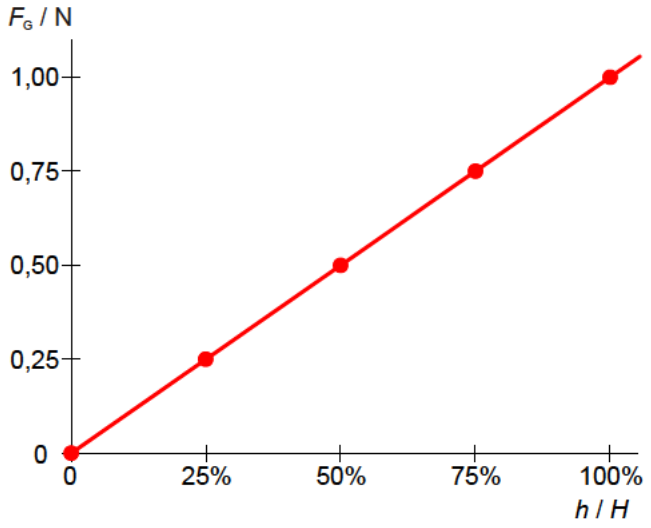

Fig. 3 Updraught F_G as a function of relative immersion depth h / H

In Fig. 3 the slope of the graph corresponds to 1 N. As seen in equation (1a), this corresponds to the product $\rho \cdot g \cdot A \cdot H$. The density of water so determined is comparable with the quoted value:

ρ = 1.0 g/mm³.