4.5 Finding the density of solid bodies by measuring the buoyancy

Task

Can the density of solid objects be determined with the aid of buoyancy?

1. Determine the buoyancy of solid bodies from the difference of their weight (force) in air and water.
2. Determine the density of the objects from their buoyancy and the volume of water displaced.

Use the space below for your own notes.

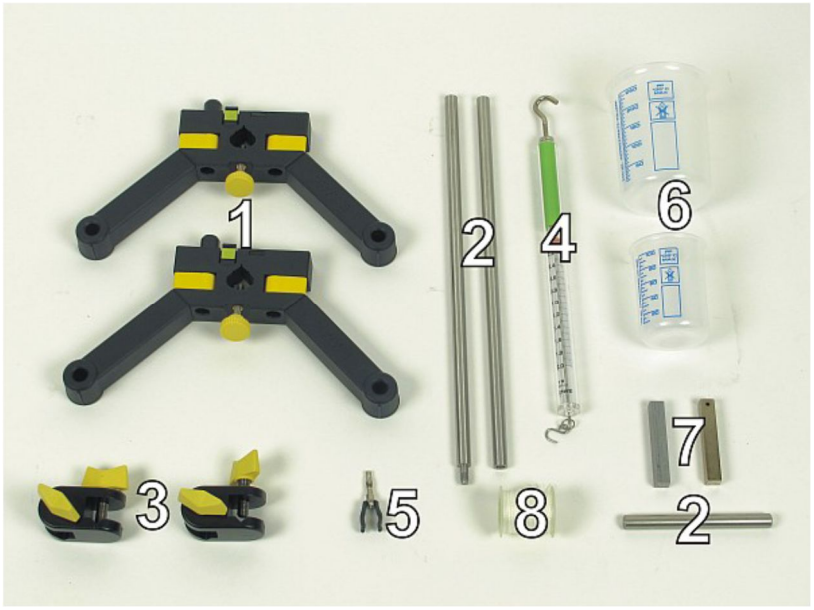
Material

Material from "TESS advanced Physics Set Mechanics 1, ME-1" (Order No. 15271-88)

Position No.	Material	Order No.	Quantity
1	Support base, variable	02001-00	1
2	Support rod with hole, stainless steel, 100 mm	02036-01	1
2	Support rod, split in 2 rods, *l* = 600 mm	02035-00	1
3	Bosshead	02043-00	2
4	Spring balance, transparent, 2 N	03065-03	1

5	Spring balance holder for transparent Spring balances	03065-20	1
6	Aluminium column	03903-00	1
6	Iron column, nickel-plated	03913-00	1
7	Beaker, plastic, short form, 100 ml	36011-01	1
7	Beaker, plastic, short form, 250 ml	36013-01	1
8	Fish line, in reel, *d* = 0.7 mm, 20 m	02089-00	20 cm
Additional Material	Scissors		1

Material required for the experiment



Setup

Screw the splitt support rod together (Fig. 1). Set up a stand with the support base (Fig. 2) and the 600 mm support rod (Fig. 3).

Fig. 1

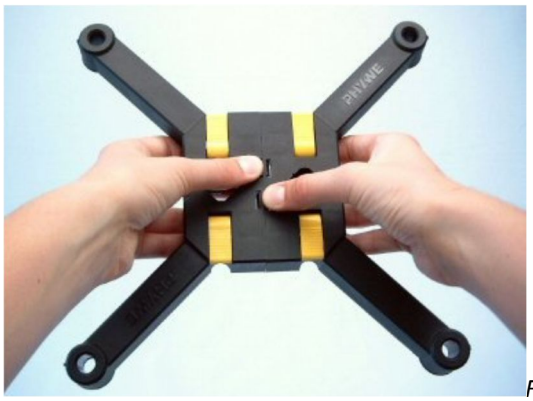


Fig. 2

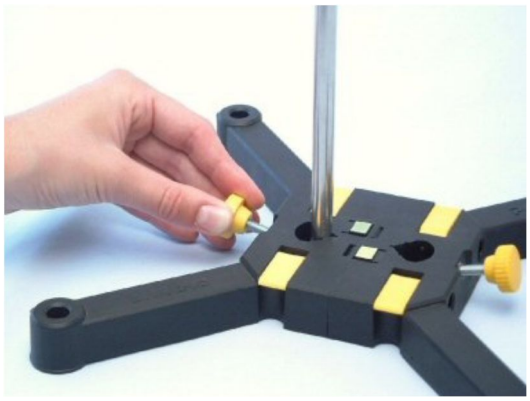


Fig. 3

Insert the spring balance holder in the blind hole in the short rod (Fig. 4). Clamp the bosshead to the long support rod and clamp the short rod in the bosshead (Fig. 5).

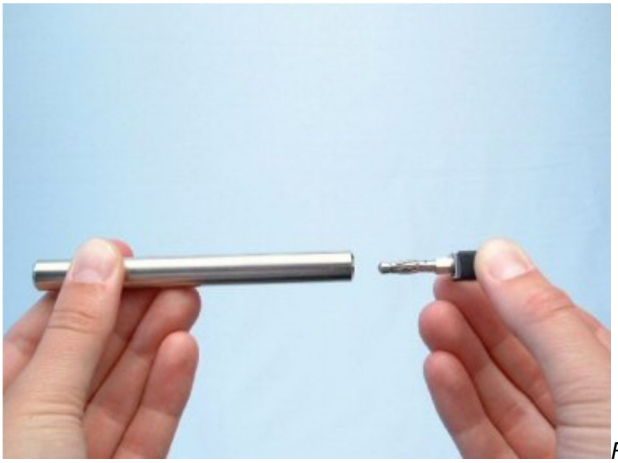


Fig. 4


Fig. 5

- Clamp the spring balance vertically in the spring balance holder (Fig. 6). If necessary, you should set the indicator of the spring balance to zero by using the adjustment screw.
- Thread a piece of fish line through the hole in the iron column and another through the hole in the aluminium one; tie a loop in each for hanging them up.
- Remove both screws from the second bosshead and attach a loop of fish line to it, too (Fig. 7).

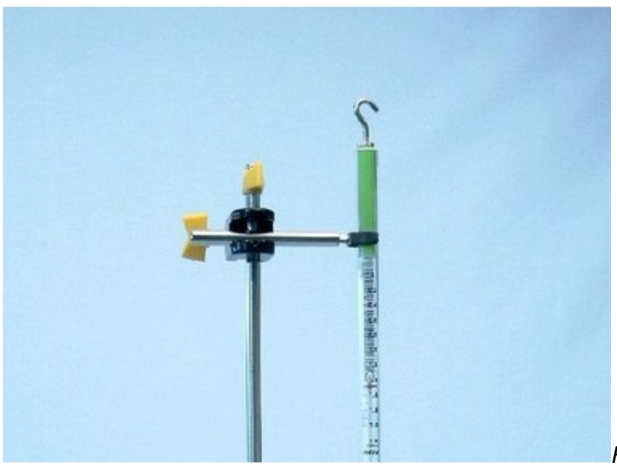


Fig. 6

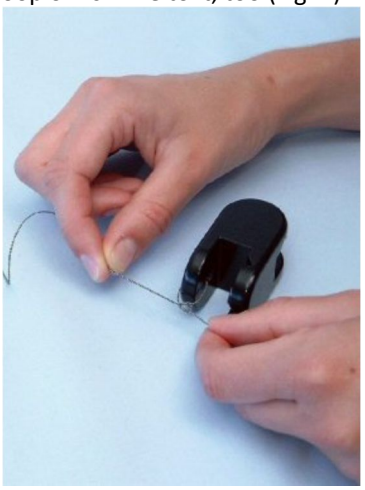


Fig. 7

Action

- Hang the aluminium column, the iron column and the bosshead one after another on the spring balance and read the weight (force) F_{ga} (Fig. 8 and Fig. 9).
- Record the values in Table 1 on the Results page.


Fig. 8


Fig. 9

- Place the large beaker which has been filled with water under the stand and immerse the 3 objects one after another in the water (Fig. 10 and Fig. 11); read the weight (force) F_{gw}.
- Record these values in Table 1, too.


Fig. 10


Fig. 11

In order to disassemble the support base you should press the yellow buttons (Fig. 12).

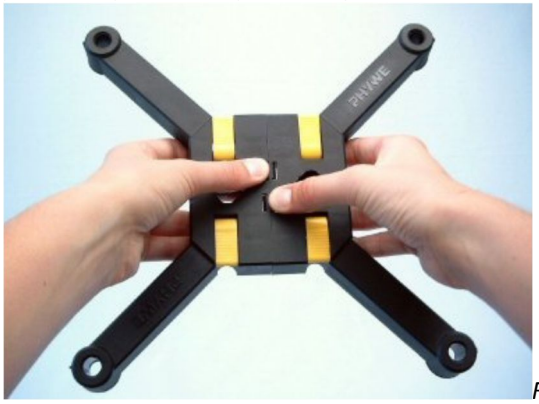


Fig. 12

Results

Table 1

Object	F_{ga} in N	F_{gW} in N	F_A in N	V in cm³	m_b in g	ρ_b in g/cm³
Aluminium column						
Iron column						
Bosshead						

Evaluation

Question 1:

Calculate the buoyancy F_A from F_{ga} - F_{gw} and add it to Table 1 on the Results page.

Question 2:

Calculate the mass m_w of the displaced water from the buoyancy F_A and the acceleration of gravity g; and, additionally, the volume V of the object using the density of water (ρ_w = 1 g/cm³).
Add these values to Table 1.

Question 3:

Calculate the mass m_b of the object from the weight (force) F_{ga} and the acceleration of gravity g.
Record the results in Table 1.

Question 4:

Form the quotients ρ_b from the mass m_b and the volume V of the objects; record the results in Table 1.

Question 5:

Think about the course of the calculations again and describe it in words or formulae:

1.

2.

3.

4.

Additional Tasks

Can you summarize the formulae in such a way that ρ_b is only a function of the weights (forces) in air and water, i.e. $\rho_b = f(F_{ga}, F_{gw})$?