

The hydrostatic pressure in a fluid can be measured with the Pascal's vase apparatus. The pressure on the bottom of the device is transferred to the pointer. It is demonstrated that the hydrostatic pressure is only dependent on the height and independent of the shape of the vessel.

Material

1 Barrel base -PASS-	02006.55
1 Pascal's vase apparatus	02638.00
1 Scale, l 1200 mm	11200.17
1 Cursors, 1 pair	02201.00
1 Glycerol, 99%, 250 ml	30084.25
1 Microspoon, steel	33393.00
1 Glass beaker DURAN®, short, 250 ml	36013.00
1 Funnel, plastic, d = 50 mm	36890.00
2 Silicone tubing i.d. 7 mm	39296.00
1 Patent blue V, 25 g	48376.04

Setup

- Press the cylinder tube all the way in the opening of the Pascal's vase apparatus, grease the sealing rings with glycerol in order to increase the slippage (Fig. 1)
- Place the funnel on the cylinder tube
- Connect the hose to the connection nipple on the back side and guide it into a drain
- The hose is used to empty the device. If the cylinder tube is inserted the opening is sealed.
- Stick the rod with the movable pointer into the device
- Place the scale in the barrel base
- Fill the glass beaker with approx. 250 ml of water and dye with a small amount of patent blue

Implementation

Experiment 1

- Place the balance weight on the pointer and move it all the way to the right
- Adjust the movable marking arrow on the device with the pointer to the cover

Fig. 1

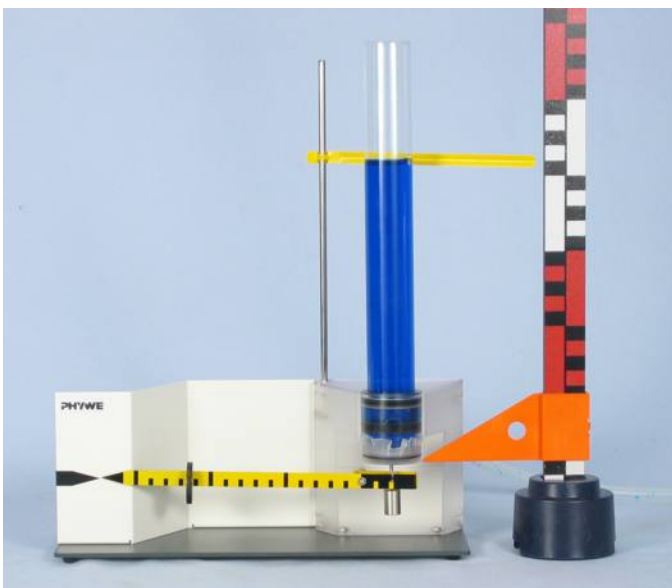
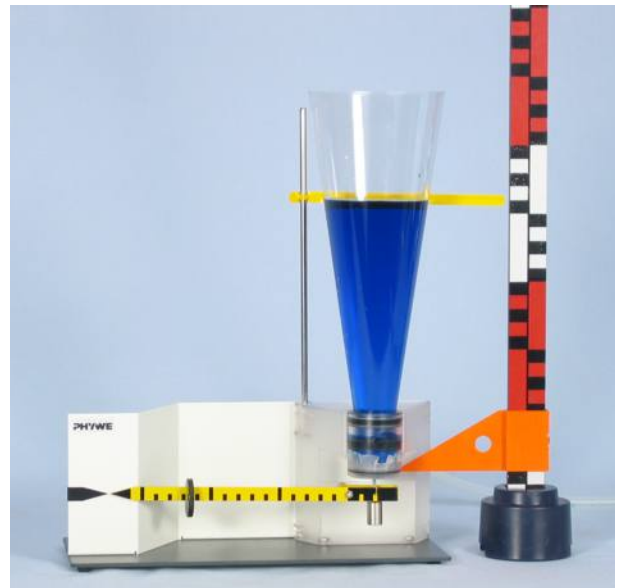


Fig. 2



- Adjust the scale cursor to the height of the rubber diaphragm of the Pascal's vase apparatus
- Adjust the pointer for the water level using the scale to a height of 6 cm above the bottom of the vessel
- Fill the cylinder tube up to this height with water
- Move the balance weight on the pointer so that it is back on the zero position
- Read the distance b of the balance weight from the initial position at the centimeter division and write it down (Table 1)
- Increase the water level h in increments of 2 cm, compensate movement of the pointer by pushing the balance weight, write down b
- Display measurement value b as a function of the water height h in a diagram

Experiment 2

- Place the hose on the device in a drain (or in the glass beaker), carefully pull slightly upward and allow the water to drain
- Take off the slotted weight
- Replace the cylindrical tube with another vessel (Fig. 2)
- Adjust the filling height marking to a fixed height (e.g. 14 cm), fill the vessel up to this height with water
- Move the balance weight until the pointer has reached the initial position again, write down b
- Repeat the experiment with the other vessels with the same filling height

Observation and measurement results

Experiment 1

The higher the water rises in the cylinder tube, the further the balance weight must be moved towards the outside in order to adjust the pointer back to zero position.

Table 1

h/cm	0	6	8	10	12	14	16	18	20	22
b/cm	0	3.7	4.9	5.7	6.9	8	9.5	10.7	11.7	12.6

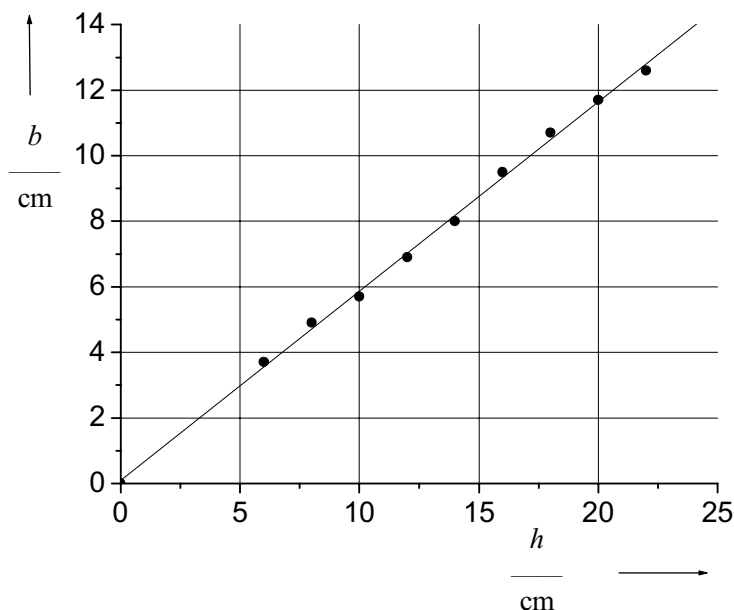


Fig. 3

Experiment 2

The slotted weight is adjusted exactly the same for all of the vessel shapes at the same filling height.

Table 2

	<i>h/cm</i>	<i>b/cm</i>
cylinder tube	14	8
conical vessel	14	8
bent tube	14	8
thin tube	14	8

Evaluation

Experiment 1

The hydrostatic pressure that exists at the bottom of the device causes the rubber diaphragm to bulge. The deformation is transferred to a pointer. The higher the water in the vessel, the greater the pressure and the more the pointer deflects.

The movement of the pointer is compensated by the weight that is placed on the left lever arm. The wider the pointer deflects, the further the weight must be moved to the left in order to bring the pointer back to zero position (compensation measuring).

The principle of the lever applies in which the product from the effort and effort arm is equal to the product from the load and load arm, Fig. 4:

$$F_w \cdot b = F \cdot a$$

Transforming the equation results in the force acting on the right lever:

$$F = \frac{F_w \cdot b}{a}$$

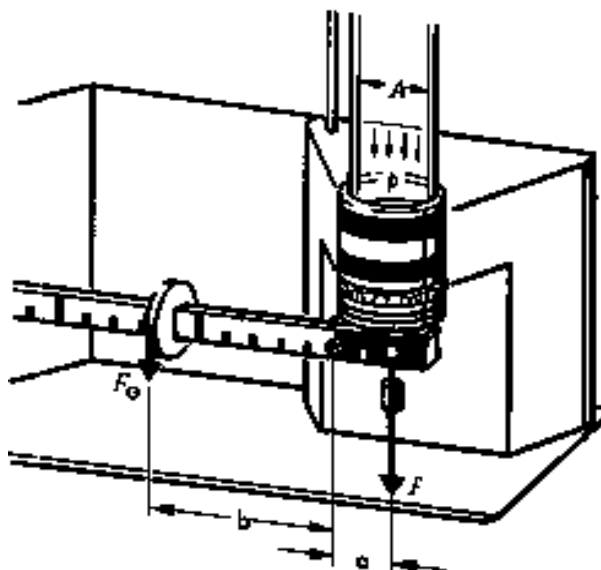


Fig. 4

$$F_G = F_W$$

The following formula applies for the pressure:

$$p = \frac{F}{A}$$

The pressure exerted can be calculated as:

$$p = \frac{F_W \cdot b}{a \cdot A}$$

The weight force of the slotted weight is:

$$F_W = m \cdot g$$

$m = 0.018$ kg and $g = 9.81$ N/kg gives:

$$F_W = 0.018 \text{ kg} \cdot 9.81 \text{ N/kg} \approx 0.18 \text{ N}$$

The length of the right lever is: $a = 2$ cm.

The bottom area of the device can be calculated as:

$$A = \pi \cdot r^2 = \frac{\pi}{4} d^2$$

With: $d = 2.6$ cm gives:

$$A = 5.31 \text{ cm}^2 = 5.31 \cdot 10^{-4} \text{ m}^2$$

The acting pressure p is:

$$p = \frac{F_W \cdot b}{a \cdot A} = \frac{0.18 \text{ N} \cdot b}{0.02 \text{ m} \cdot 5.31 \cdot 10^{-4} \text{ m}^2} = 16.9 \cdot 10^3 \frac{\text{N}}{\text{m}^2}$$

Table 3

h/cm	0	6	8	10	12	14	16	18	20	22
b/m	0	0.037	0.049	0.057	0.069	0.08	0.095	0.107	0.117	0.126
p/hPa	0	6.27	8.31	9.66	11.69	13.55	16.10	18.14	19.83	21.36
$s = p/h$	-	1.05	1.04	0.97	0.97	0.97	1.01	1.01	0.99	0.97

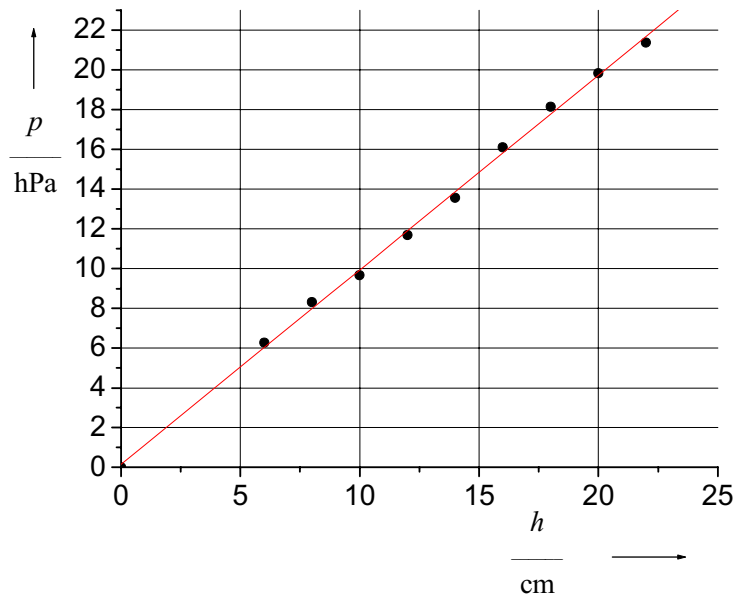


Fig. 5

The pressure p increases proportionally to the height h of the water column (Fig. 5).

The unit hPa can therefore be defined also above the height of a water column. The slope s of the line gives the proportionality factor:

$$s = \frac{p}{h}$$

The slope amounts on average to (Table 3):

$$s = 1.0$$

One cm water column therefore corresponds to 1 hPa.
(Literature value: 1 cm WC corresponds to 0.98665 hPa.)

Experiment 2

The hydrostatic pressure which a fluid exerts on the bottom of a container does not depend on the shape of the container. For all vessel forms the following applies: The pressure is proportional to the height of the water column.

Remarks

The balance weight hanging under the right lever arm is only used as a compensation weight for the weight of the left pointer and does not need to be integrated into the calculation.

Room for notes