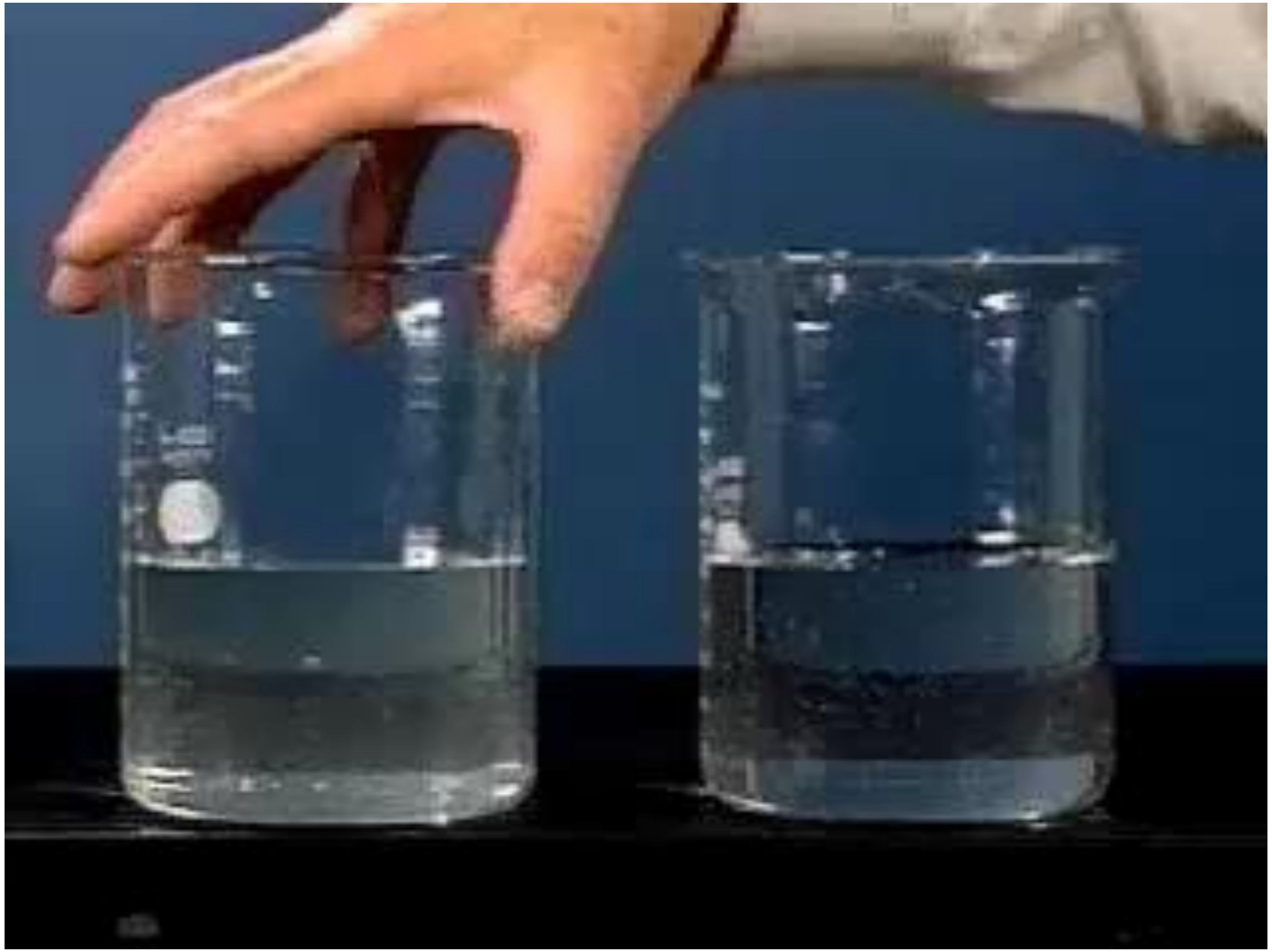
02 Fluida

Sifat fisika fluida, rapat massa, tekanan hidrostatik

Fluida

- Kumpulan molekul yang tersusun secara acak dan saling terikat dengan gaya kohesi yang lemah serta gaya yang didesakkan dari dinding-dinding suatu ruangan.
- Bahan yang dapat mengalir, menempati ruang dengan batas tertentu.
- Fluida tidak dapat menahan gaya gesek, namun dapat memberikan gaya tegak lurus pada permukaan tertentu.



Density and Pressure

Density

$$\rho = \frac{m}{V}$$

m : massa bahan (g)

V : volume bahan (cm^3)

Pressure

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

F : gaya (N)

A : luas permukaan (m^2)

Table 14-1 Some Densities

Material or Object	Density (kg/m^3)
Interstellar space	10^{-20}
Best laboratory vacuum	10^{-17}
Air: 20°C and 1 atm pressure	1.21
20°C and 50 atm	60.5
Styrofoam	1×10^2
Ice	0.917×10^3
Water: 20°C and 1 atm	0.998×10^3
20°C and 50 atm	1.000×10^3
Seawater: 20°C and 1 atm	1.024×10^3
Whole blood	1.060×10^3
Iron	7.9×10^3
Mercury (the metal, not the planet)	13.6×10^3
Earth: average	5.5×10^3
core	9.5×10^3
crust	2.8×10^3
Sun: average	1.4×10^3
core	1.6×10^5
White dwarf star (core)	10^{10}
Uranium nucleus	3×10^{17}
Neutron star (core)	10^{18}

Example

The mattress of a water bed is 2.00 m long by 2.00 m wide and 30.0 cm deep.

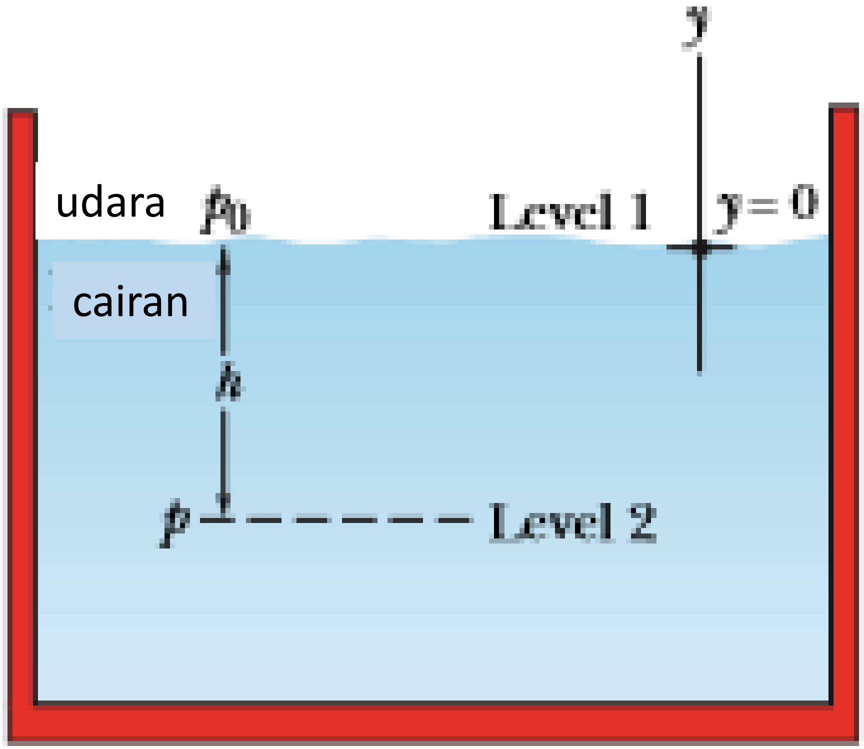
(A) Find the weight of the water in the mattress.

(B) Find the pressure exerted by the water on the floor when the bed rests in its normal position. Assume that the entire lower surface of the bed makes contact with the floor.

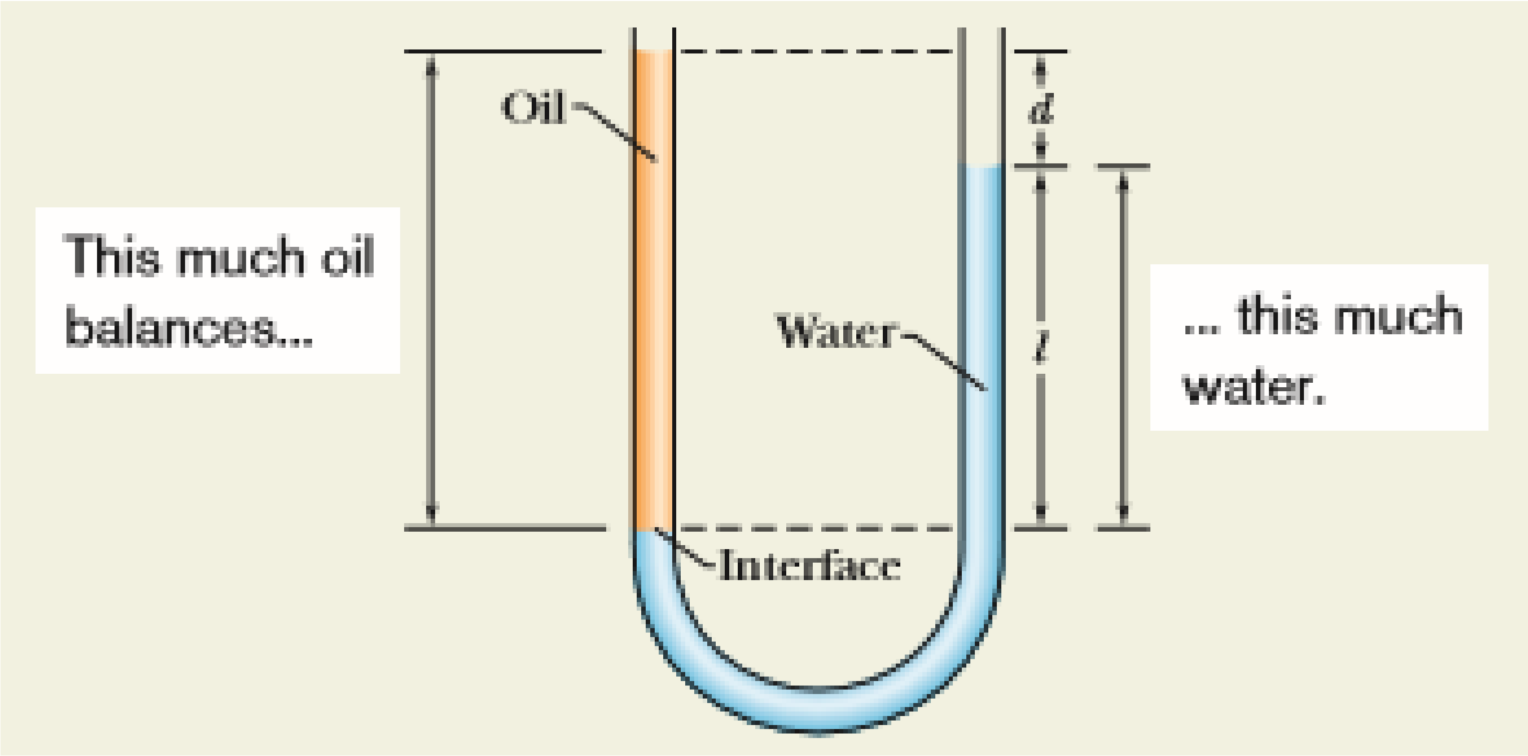
Variasi tekanan pada kedalaman fluida

Tekanan pada kedalaman tertentu dalam suatu tangki :

$$p = p_0 + \rho g h$$

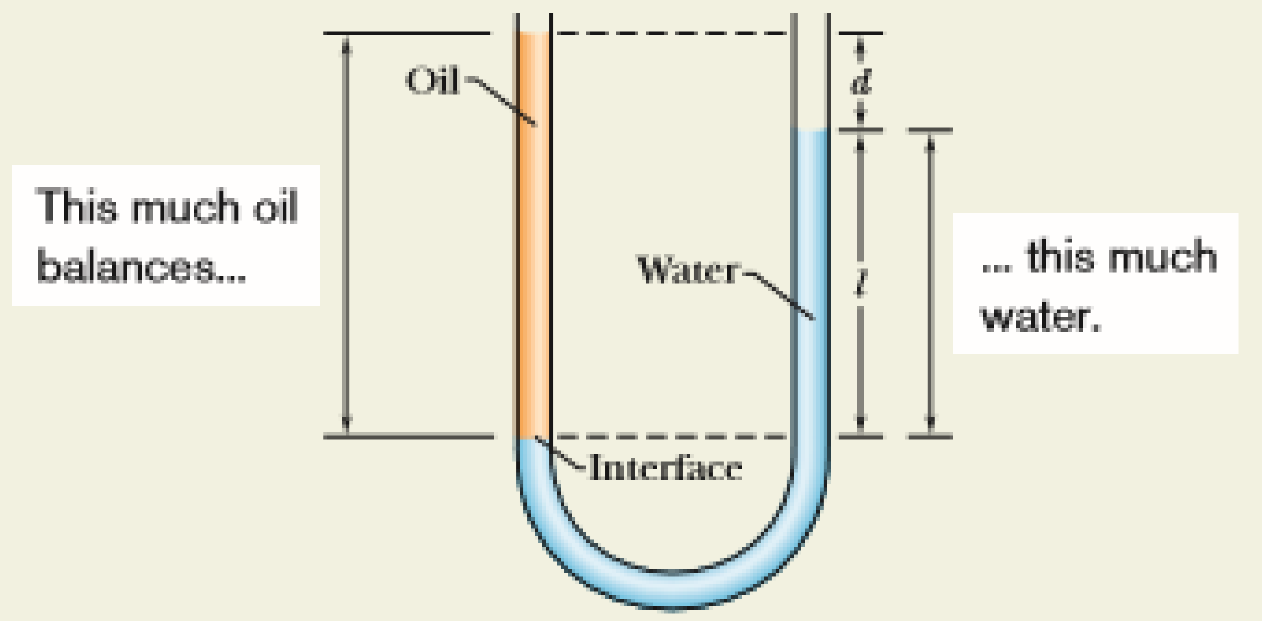


Tabung U pada gambar di bawah berisi 2 cairan yg setimbang secara statis. Air berdensitas ρ_w = 998 kg/m^3 di sisi kanan, dan minyak dengan densitas yang tidak diketahui di sisi kiri. Hasil pengukuran menunjukkan l = 135 mm dan d = 12.3 mm. Berapa densitas minyak?



$$p_{int} = p_0 + \rho_w g l$$

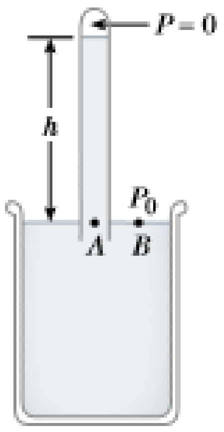
$$p_{int} = p_0 + \rho_x g(l + d)$$



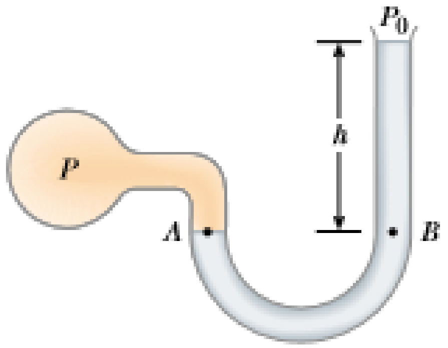
$$\rho_x = \rho_w \frac{l}{l + d} = (998\ \text{kg/m}^3)\,\frac{135\ \text{mm}}{135\ \text{mm} + 12.3\ \text{mm}}$$

$$= 915\ \text{kg/m}^3. \qquad \text{(Answer)}$$

Pengukuran tekanan



(a)



(b)

Figure 14.6 Two devices for measuring pressure: (a) a mercury barometer and (b) an open-tube manometer.

atmosphere of pressure, $P_0 = 1\text{ atm} = 1.013 \times 10^5\text{ Pa}$:

$$P_0 = \rho_{Hg} g h \longrightarrow h = \frac{P_0}{\rho_{Hg} g} = \frac{1.013 \times 10^5\text{ Pa}}{(13.6 \times 10^3\text{ kg/m}^3)(9.80\text{ m/s}^2)} = 0.760\text{ m}$$

Tekanan pada titik A dan B sama. Tekanan pada A adalah tekanan gas yang belum diketahui.

P = Po + ρgh

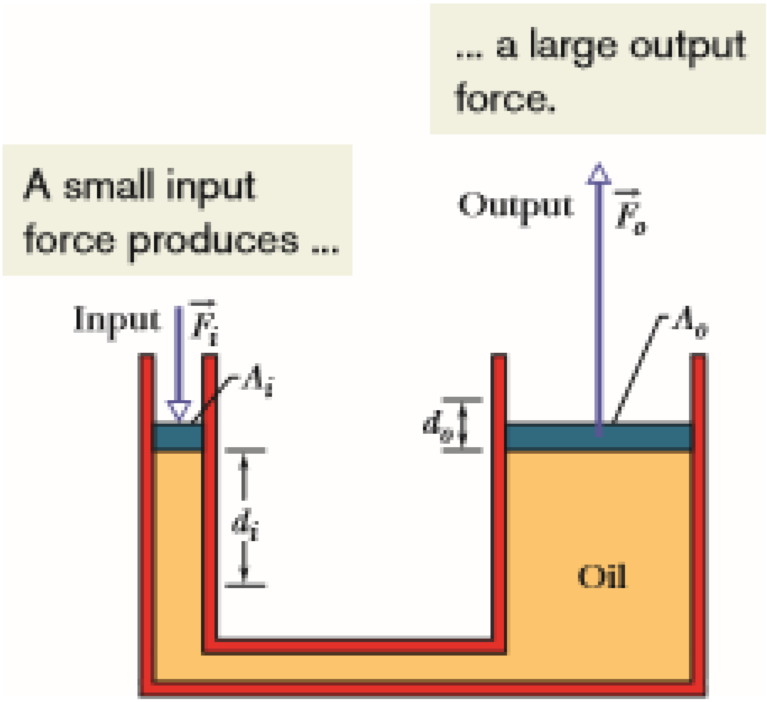
P - Po = ρgh

P : tekanan absolut

P - Po : tekanan gauge.

Pascal's Principle

Perubahan tekanan yang diaplikasikan pada suatu fluida incompressible dalam ruangan tertutup diteruskan ke setiap bagian fluida dan pada seluruh dinding wadah.



$$\Delta p = \frac{F_i}{A_i} = \frac{F_o}{A_o},$$

$$F_o = F_i \frac{A_o}{A_i}.$$

Gaya apung (buoyant forces) dan *Archimedes's Principle*

Buoyant force :

gaya ke atas yang digunakan suatu fluida untuk melawan gaya akibat benda yang dibenamkan

Archimedes's principle :

Besarnya gaya apung selalu sama dengan berat fluida yang dipindahkan oleh benda tersebut.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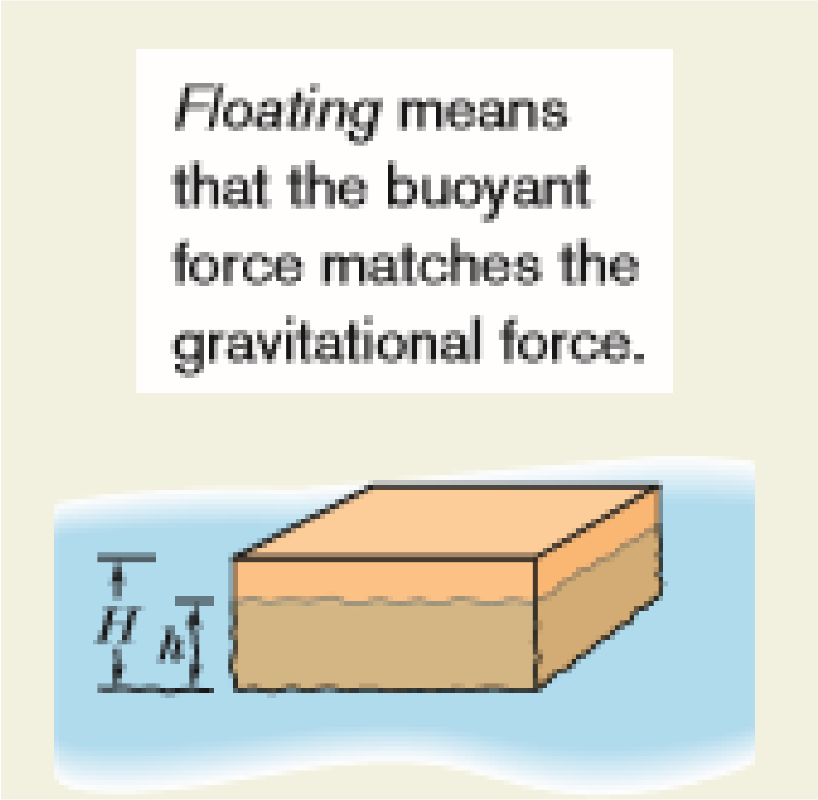
In Fig., a block of density $\rho = 800\ kg/m^3$ floats face down in a fluid of density $\rho_f = 1200\ kg/m^3$. The block has height H = 6 cm.

(a) By what depth is the block submerged?

(b) If the block is held fully submerged and then released, what is the magnitude of its acceleration?



Gaya apung :

$$F_g = mg = \rho V g = \rho_f LWHg.$$

- Gaya gravitasi :

$$F_g = mg = \rho V g = \rho_f LWHg.$$

- F net = m.a dengan a = 0

$$F_b - F_g = m(0),$$

$$\rho_f LWhg - \rho LWHg = 0,$$

$$h = \frac{\rho}{\rho_f} H = \frac{800 \text{ kg/m}^3}{1200 \text{ kg/m}^3}(6.0 \text{ cm})$$
$$= 4.0 \text{ cm}.$$

$$F_b - F_g = ma,$$

$$\rho_f LWHg - \rho LWHg = \rho LWHa,$$

$$a = \left(\frac{\rho_f}{\rho} - 1\right)g = \left(\frac{1200 \text{ kg/m}^3}{800 \text{ kg/m}^3} - 1\right)(9.8 \text{ m/s}^2)$$
$$= 4.9 \text{ m/s}^2.$$

(Answe

Dinamika fluida

Fluida ideal memiliki ciri-ciri :

1. *Nonviscous* (encer)
2. *Steady/laminar flow* (kecepatan alir tetap)
3. *Incompressible* (tak dapat ditekan, densitas konstan)
4. *Irrotational* (tak dapat berputar)

Persamaan kontinyuitas fluida

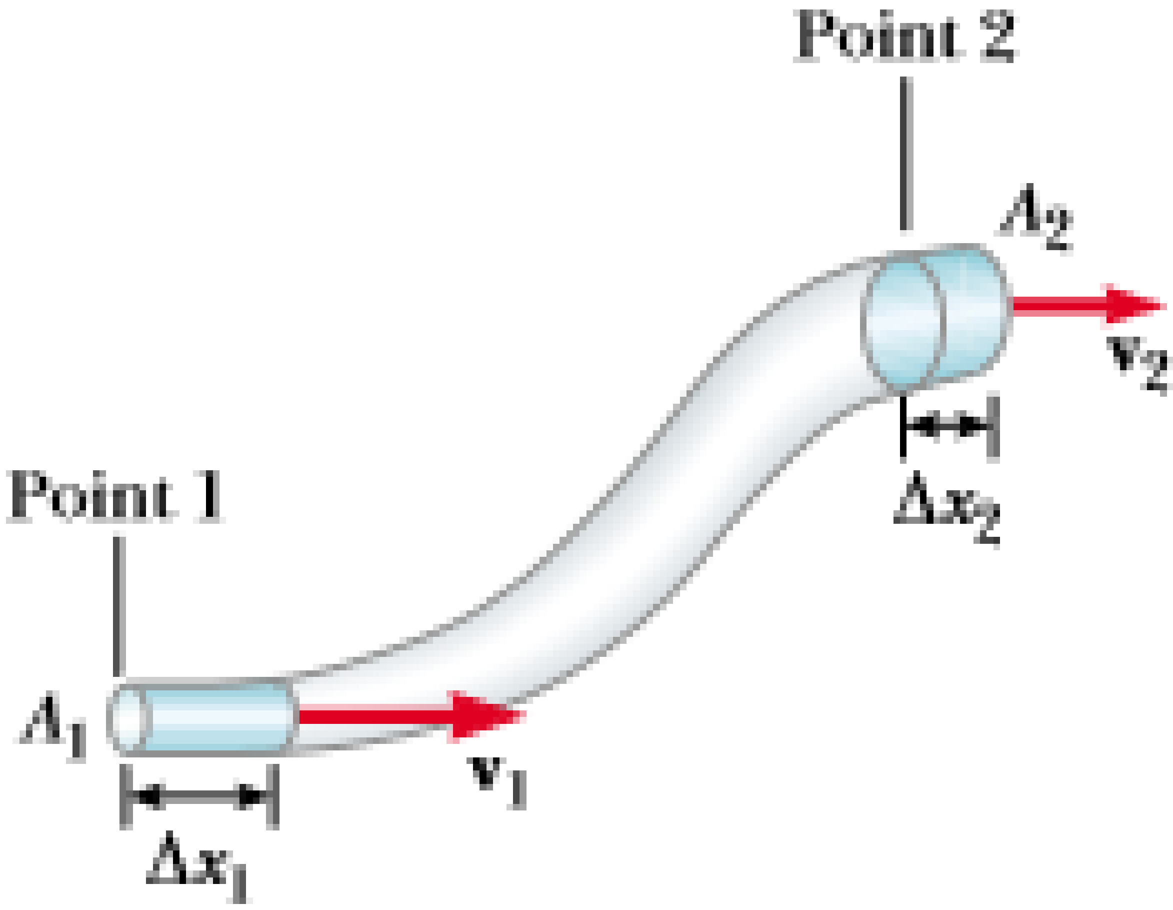
$$\Delta V = A\,\Delta x = Av\,\Delta t.$$

$$\Delta V = A_1 v_1\,\Delta t = A_2 v_2\,\Delta t$$

$$A_1 v_1 = A_2 v_2$$

$$R_V = Av = \text{a constant}$$

Rv : volume flowrate



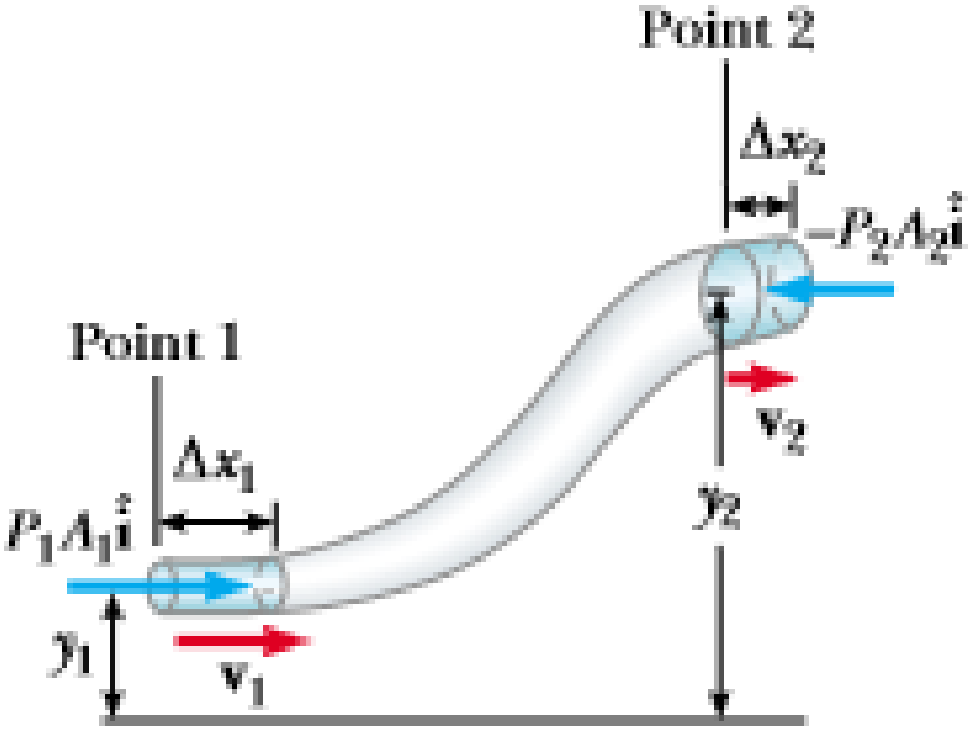
Bernoulli's equation

$$p_1 + \frac{1}{2}\rho v_1^2 + \rho g y_1 = p_2 + \frac{1}{2}\rho v_2^2 + \rho g y_2.$$

$$P + \frac{1}{2}\rho v^2 + \rho g y = \text{constant}$$

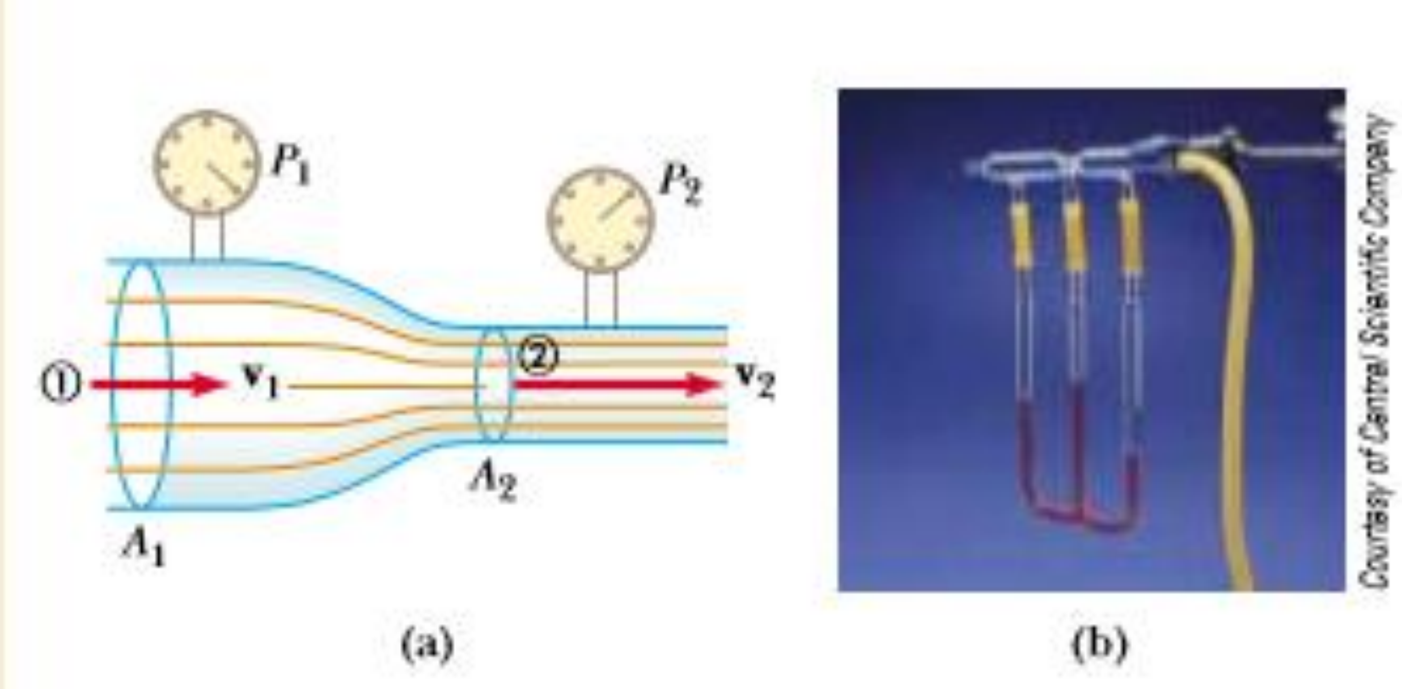
Pada ketinggian yang sama :

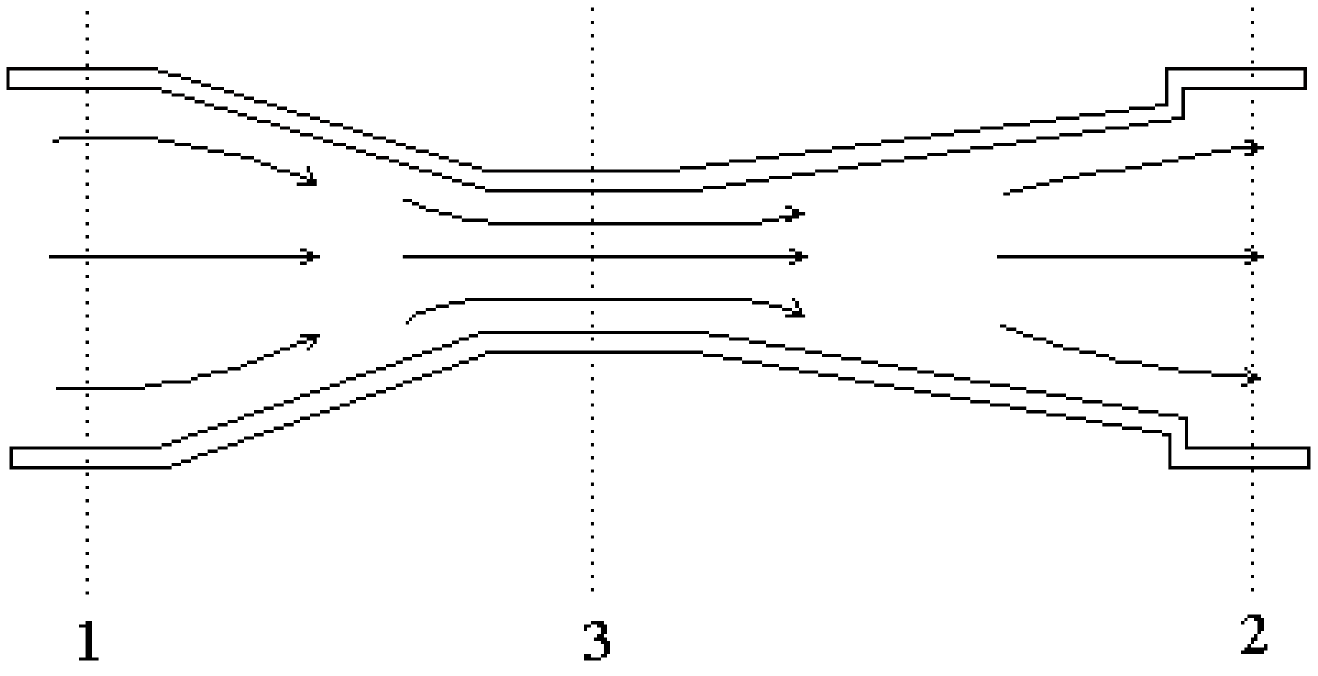
$$p_1 + \frac{1}{2}\rho v_1^2 = p_2 + \frac{1}{2}\rho v_2^2,$$

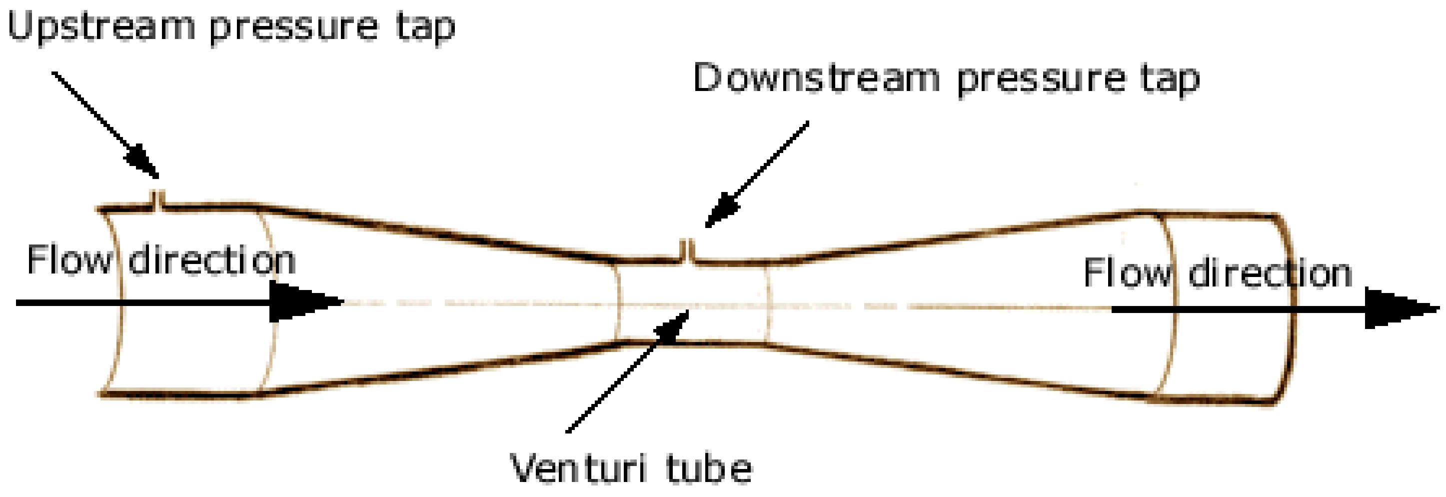


Venturi tube

Digunakan untuk mengukur kecepatan alir fluida incompressible. Kecepatan alir pada titik 2 dapat dihitung bila diketahui beda tekanan antara posisi 1 dan 2.




1
3
2


Upstream pressure tap
Downstream pressure tap
Flow direction
Flow direction
Venturi tube

Solution Because the pipe is horizontal, $y_1 = y_2$, and applying Equation 14.8 to points 1 and 2 gives

$$(1) \qquad P_1 + \tfrac{1}{2}\rho v_1^2 = P_2 + \tfrac{1}{2}\rho v_2^2$$

From the equation of continuity, $A_1 v_1 = A_2 v_2$, we find that

$$(2) \qquad v_1 = \frac{A_2}{A_1} v_2$$

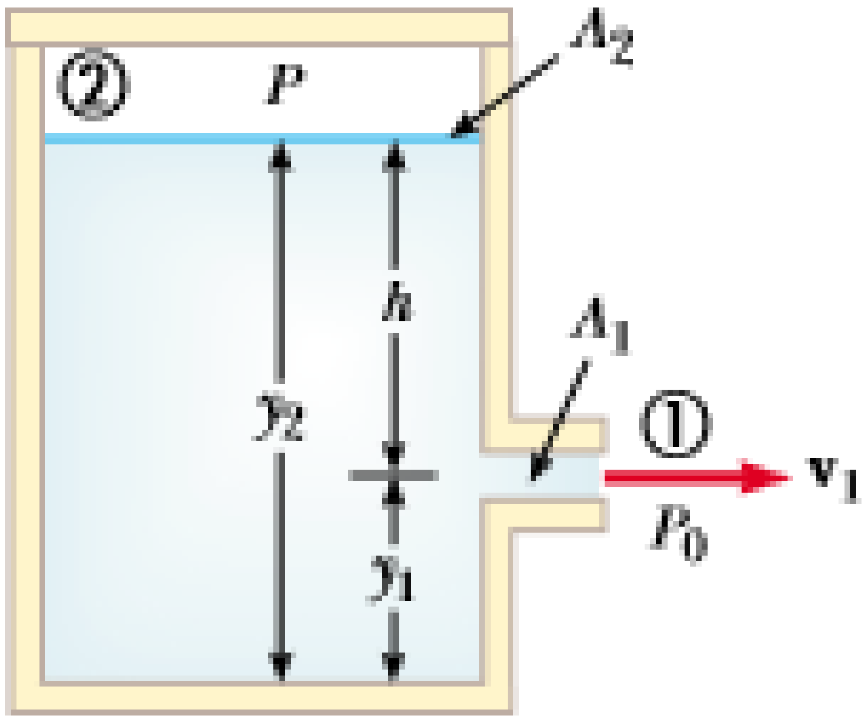
Substituting this expression into Equation (1) gives

$$P_1 + \tfrac{1}{2}\rho\left(\frac{A_2}{A_1}\right)^2 v_2^2 = P_2 + \tfrac{1}{2}\rho v_2^2$$

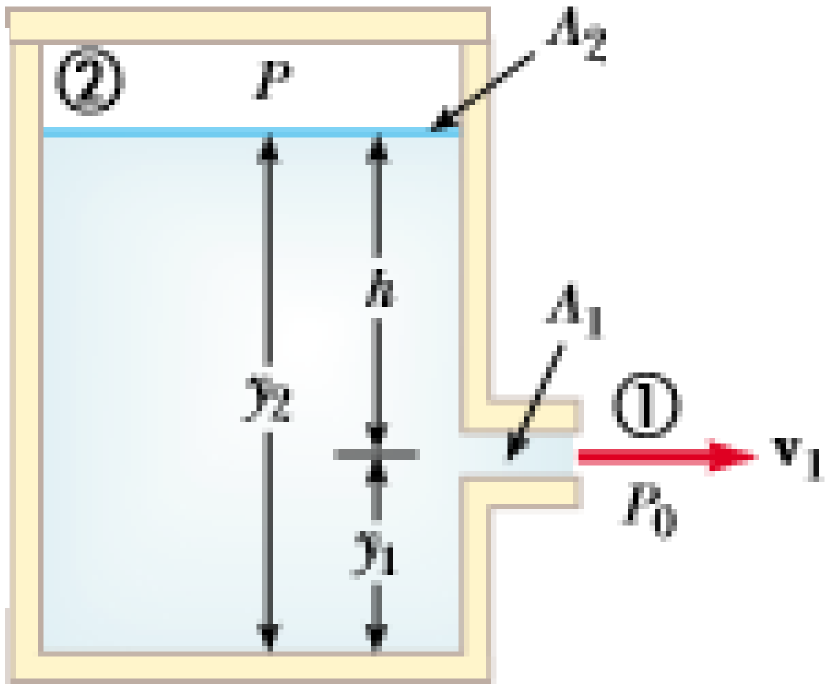
$$v_2 = A_1\sqrt{\frac{2(P_1 - P_2)}{\rho(A_1^2 - A_2^2)}}$$

Torricelli's Law

An enclosed tank containing a liquid of density has a hole in its side at a distance y1 from the tank's bottom. The hole is open to the atmosphere, and its diameter is much smaller than the diameter of the tank. The air above the liquid is maintained at a pressure P. Determine the speed of the liquid as it leaves the hole when the liquid's level is a distance h above the hole.



Solution Because $A_2 \gg A_1$, the liquid is approximately at rest at the top of the tank, where the pressure is P. Applying Bernoulli's equation to points 1 and 2 and noting that at the hole P_1 is equal to atmospheric pressure P_0, we find that



$$P_0 + \tfrac{1}{2}\rho v_1^2 + \rho g y_1 = P + \rho g y_2$$

But $y_2 - y_1 = h$; thus, this expression reduces to

$$v_1 = \sqrt{\frac{2(P - P_0)}{\rho} + 2gh}$$