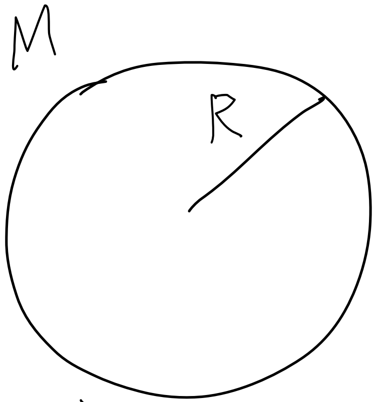
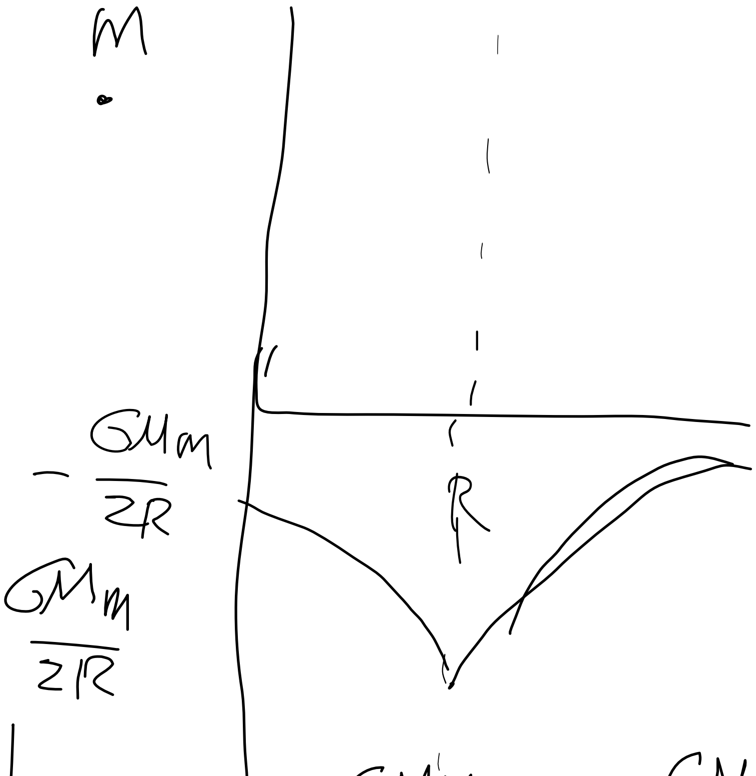
Copyright statement

- The images and the pictures in this lecture are provided by the CDs accompanied by the books
  1. University Physics, Bauer and Westfall, McGraw-Hill, 2011.
  2. Principles of Physics, Halliday, Resnick, and Walker, Wiley, 8th and 9th Ed.
- The rest is made by me.

지구 중심의 퍼텐셜에너지





$r>R$

i) $U = -\frac{GMm}{r}$

ii) $r<R$

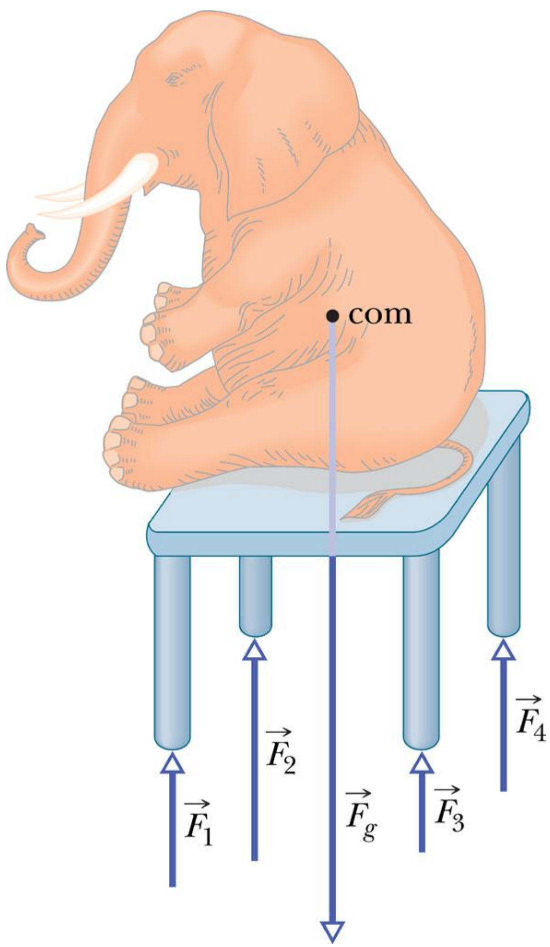
$$F = \frac{GMm}{R^3} r = -\frac{dU}{dr}$$

$-\frac{GMm}{2R}$

$$U = -\frac{GMm}{R^3}\frac{r^2}{2} + A \rightarrow -\frac{GMm}{2R} + A = -\frac{GMm}{R}$$

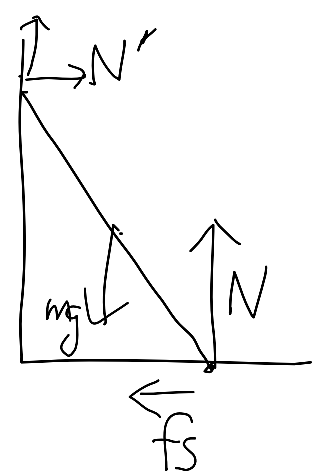
Chapter 13. Solids & Fluids

Indeterminate structure

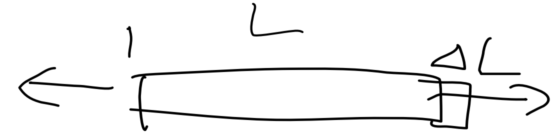


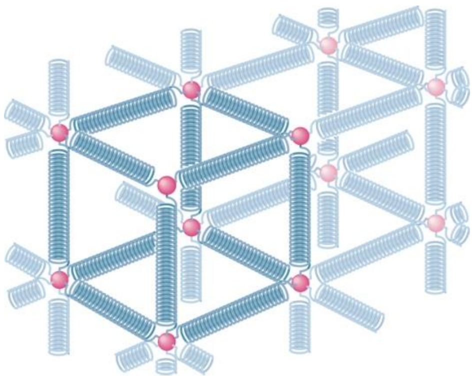
힘에 대한 식 2개, 돌림힘에 대한 식 1개
→ 미지수가 4개이면 풀 수 없다.
→ indeterminate structure

3개의 다리일 때는 풀 수 있다.
4개의 다리는 풀 수 없나?
→ 탄성에 의한 변형을 고려



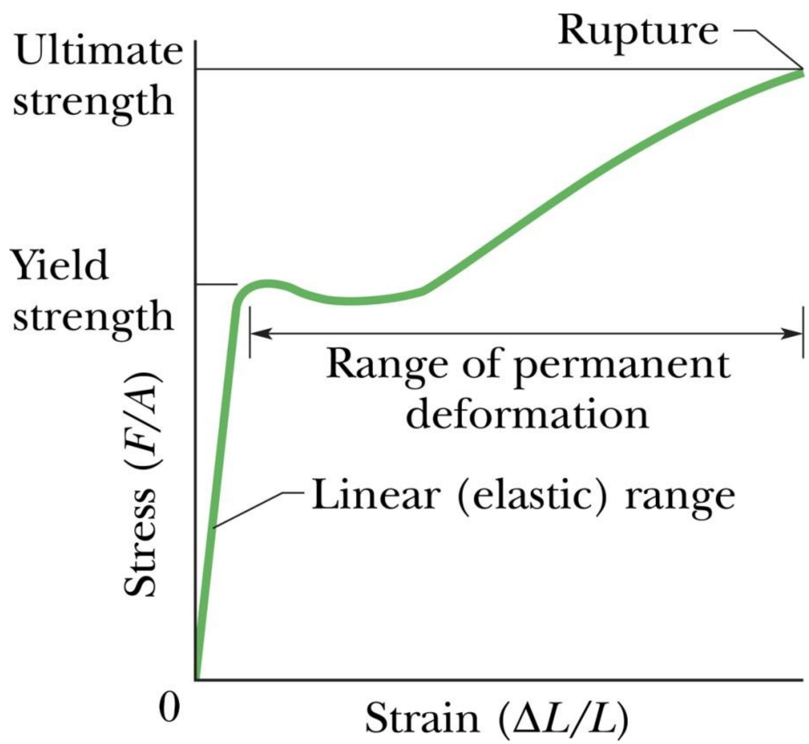
elasticity

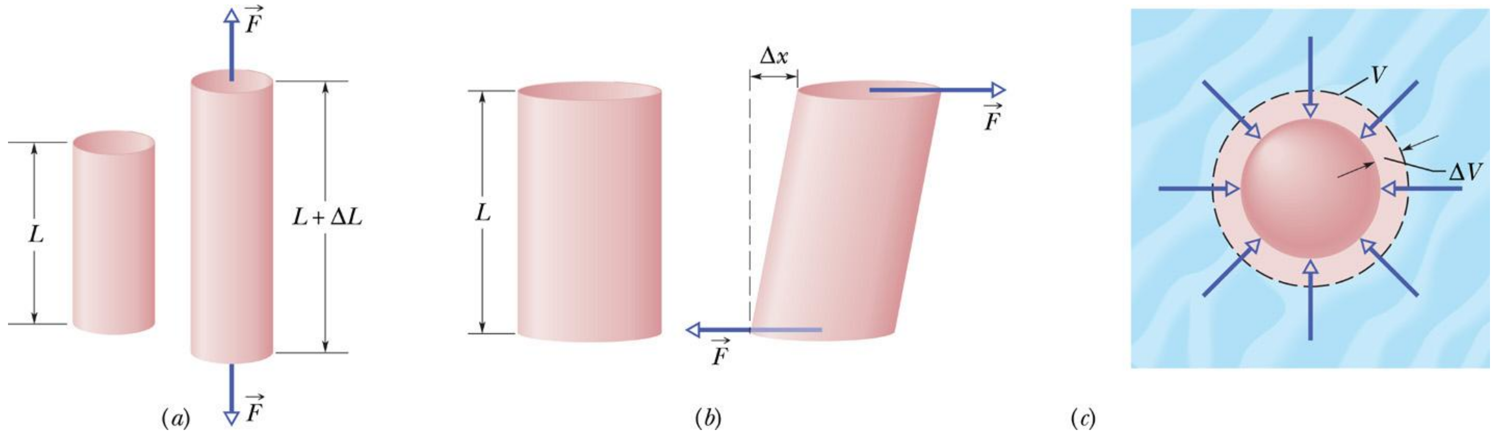




$$\text{stress} = \text{modulus} \times \text{strain}$$

(탄성 한계 내에서의 관계식)





tension | shearing stress | hydraulic stress

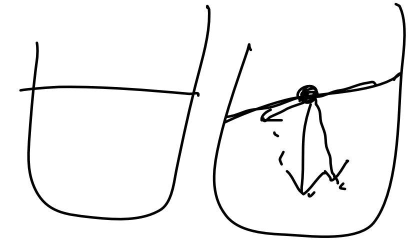
$$\frac{F}{A} = E\frac{\Delta L}{L}$$

$$\frac{F}{A} = G\frac{\Delta x}{L}$$

$$p = -B\frac{\Delta V}{V}$$

E: Young's modulus | G: shear modulus | B: bulk modulus atmospheric pressure

Fluid의 밀도



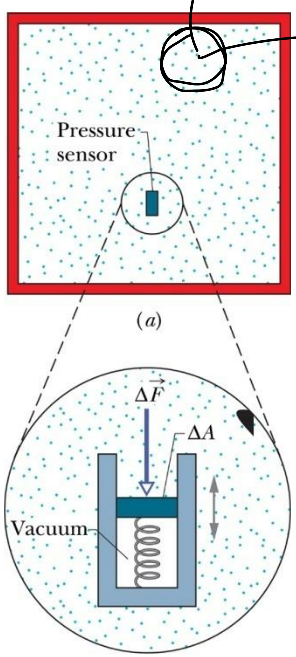
Fluid란? 표면의 접선방향의 힘을 받을 수 없는 물질

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

균일한 밀도 $$\rho = \frac{m}{V}$$

Pascal

Torricelli



(a) (b)

압력 $$p = \frac{\Delta F}{\Delta A}$$

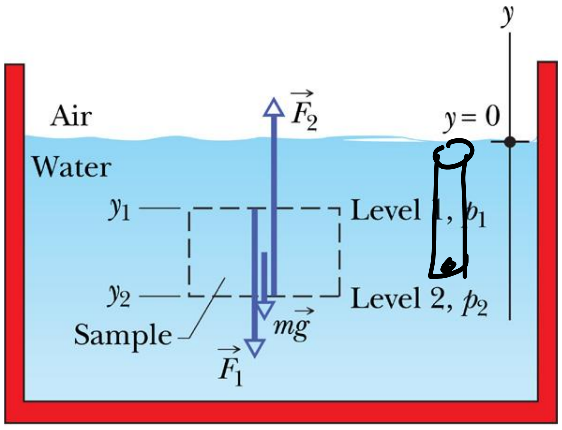
단위: $\mathrm{N/m^2}$ 차원 $ML^{-1}T^{-2}$

$$1\ \mathrm{N/m^2} = 1\ \mathrm{Pa}$$

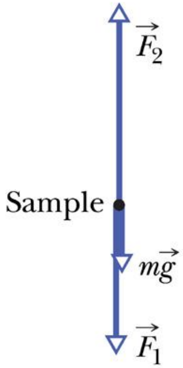
mmHg

$$1\ \mathrm{atm} = 1.01 \times 10^5\ \mathrm{Pa} = 760\ \mathrm{torr}$$

정지해 있는 유체



(a)



(b)

$$F_2 = F_1 + mg$$

$$F_1 = p_1 A, \;\; F_2 = p_2 A$$

$$p_2 A = p_1 A + \rho A g (y_1 - y_2)$$

$$p_2 = p_1 + \rho g (y_1 - y_2)$$

$$y_1 = 0, \;\; p_1 = p_0, \;\;\; y_2 = -h, \;\; p_2 = p$$

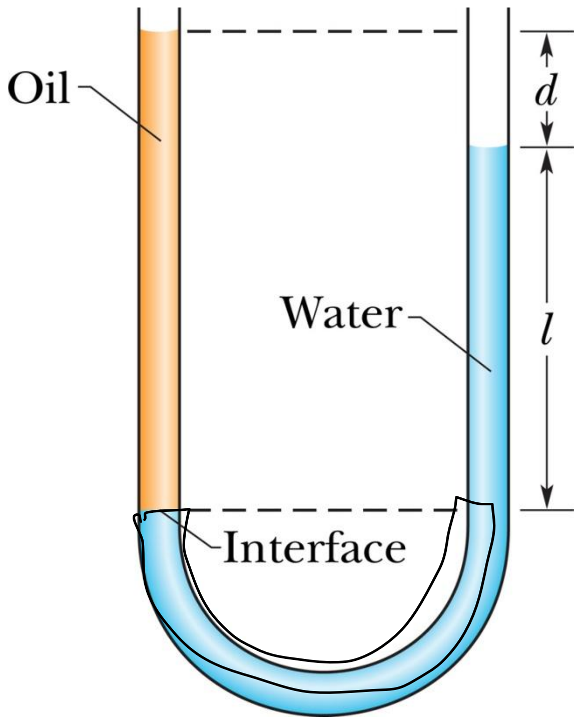
$$p = p_0 + \rho g h$$

절대압력

계기압력

공기중에서 $p = p_0 - \rho_{\text{air}} g d$

Sample prob.



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

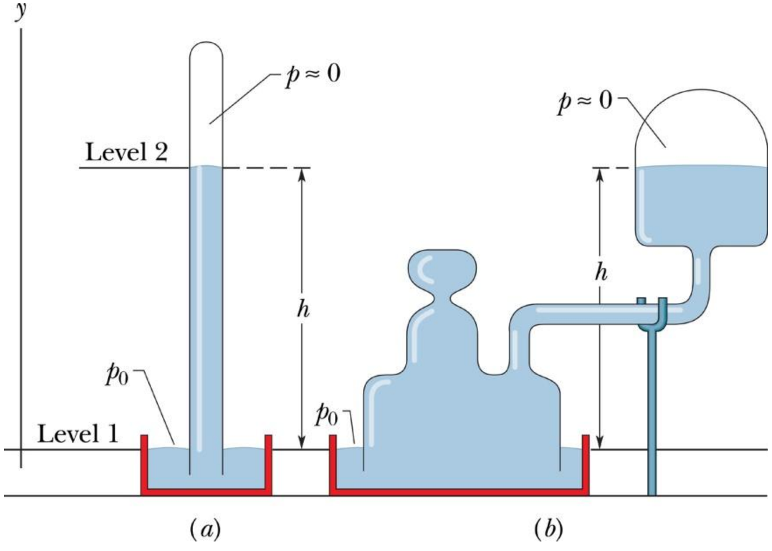
왼쪽 $p_{\text{int}} = p_0 + \rho_x g (l + d)$

$\rho_w l = \rho_x (l + d)$

$$\rho_x = \rho_w \frac{l}{l + d}$$

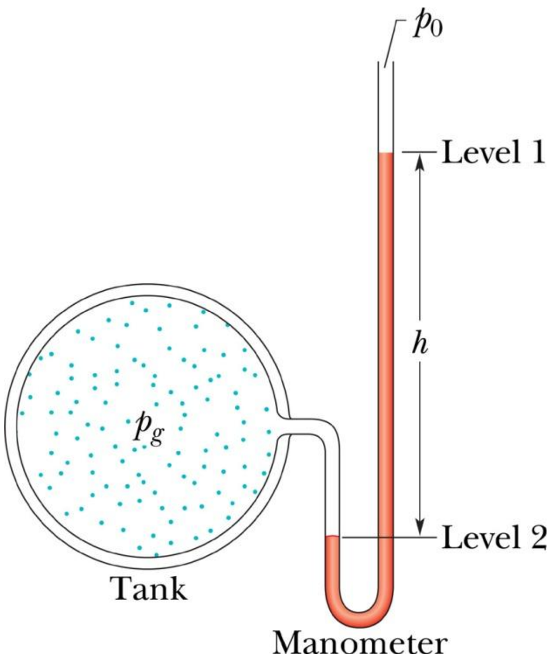
압력의 측정

수은 기압계



$$p_0 = \rho g h$$

열린관 기압계

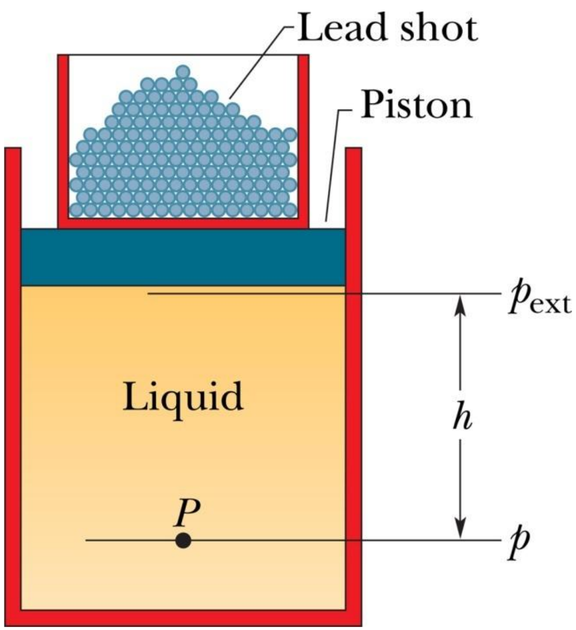


계기압력 $p_g = p - p_0 = \rho g h$

절대압력 $p = p_0 + \rho g h$

Pascal의 원리

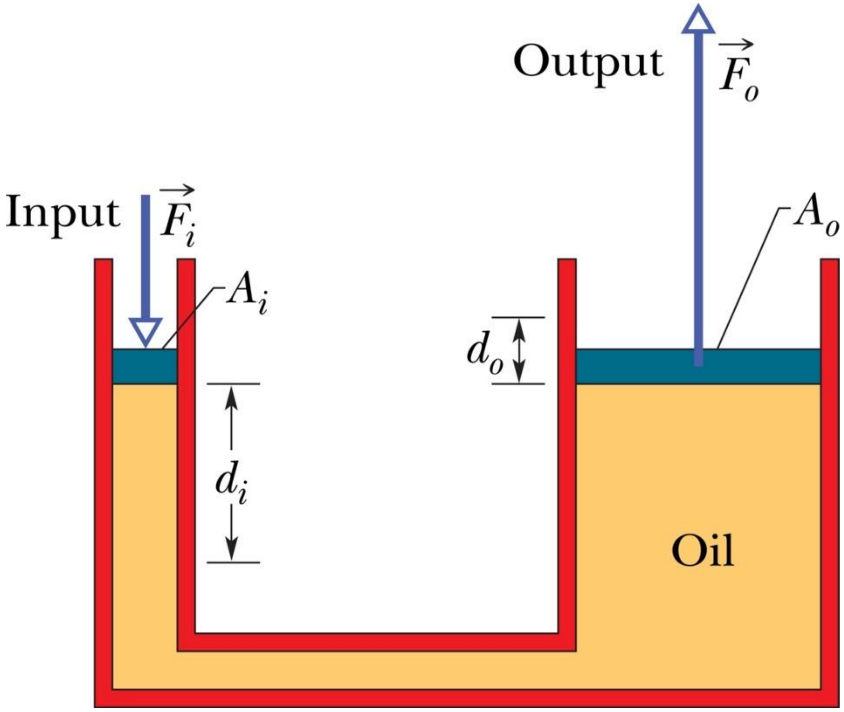
갇혀있는 비압축성 유체에 가해진 압력은 유체의 모든 부분과 유체를 담고 있는 그릇의 모든 부분에 똑같이 전달된다.



$$p = p_{\text{ext}} + \rho g h$$

$$\Delta p = \Delta p_{\text{ext}}$$

유압지렛대



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

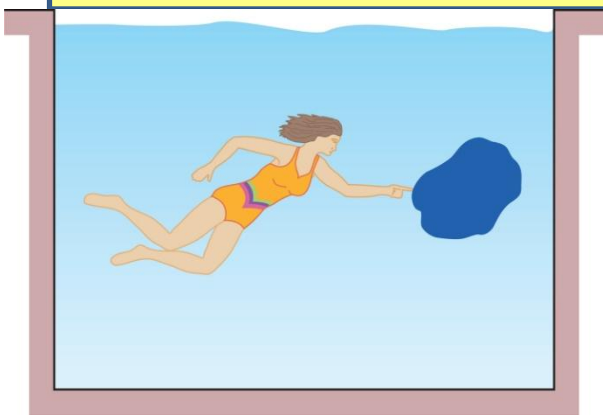
$$F_o = F_i \frac{A_o}{A_i}$$

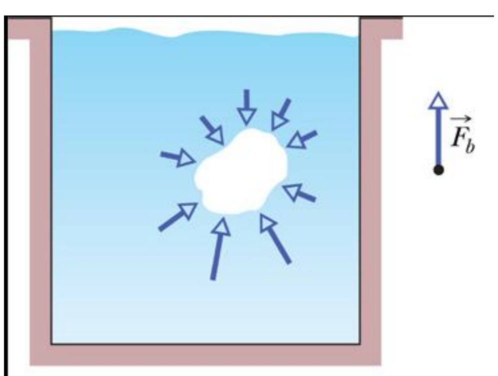
$$V = A_i d_i = A_o d_o \longrightarrow d_o = d_i \frac{A_i}{A_o}$$

$$W = F_o d_o = \left(F_i \frac{A_o}{A_i}\right)\left(d_i \frac{A_i}{A_o}\right) = F_i d_i$$

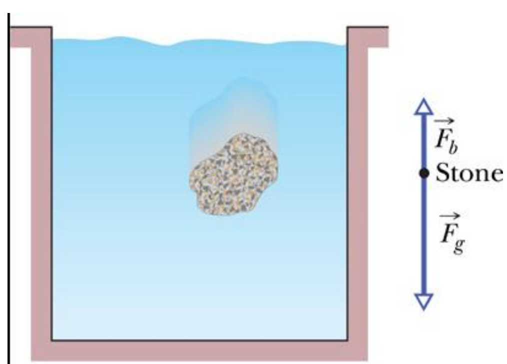
Archimedes의 원리

물체가 유체에 잠기면 잠긴 물체가 밀어낸 유체의 무게와 같은 크기의 부력이 위쪽으로 작용한다.

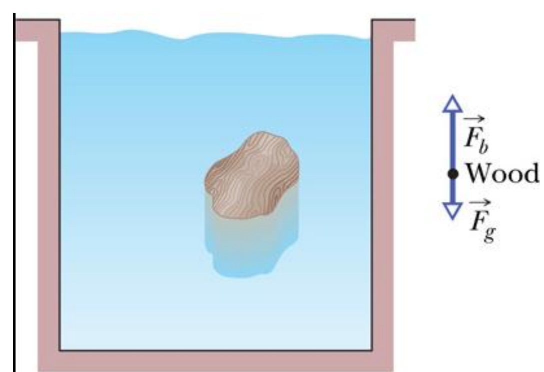




(a)



(b)

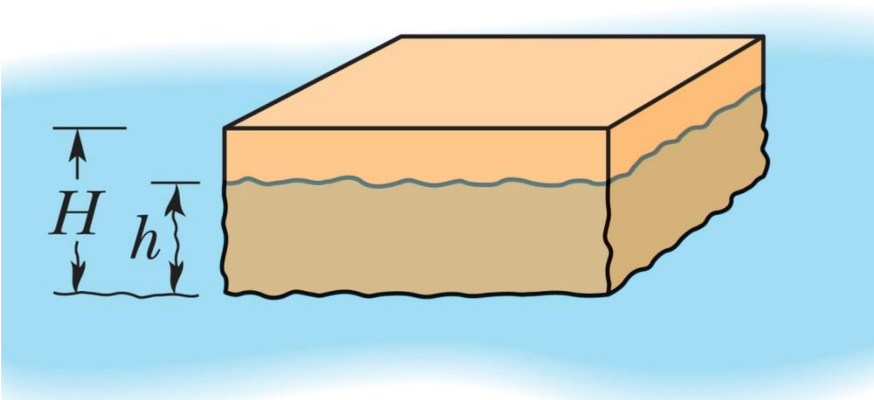


(c)

boy
buoy

Sample prob.

buoyant force



(a) h=?

$$F_b = m_f g = \rho_f V_f g = \rho_f LWhg$$

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

$$h = \frac{\rho}{\rho_f} H$$

$$\rho = 800 \text{ kg/m}^3,\ \rho_f = 1200 \text{ kg/m}^3,\ H = 6.0 \text{ cm}$$

$$(\rho_f - \rho) g = \rho a$$

(b) 가속도?

$$F_b - F_g = ma \qquad \rho_f LWHg - \rho LWHg = \rho LWHa$$

$$a = \left(\frac{\rho_f}{\rho} - 1\right) g$$

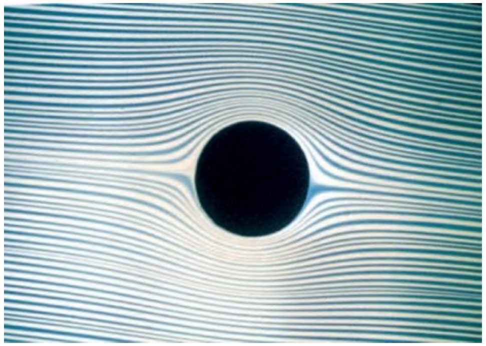
$$a = \left(\frac{\rho_f}{\rho} - 1\right) g$$

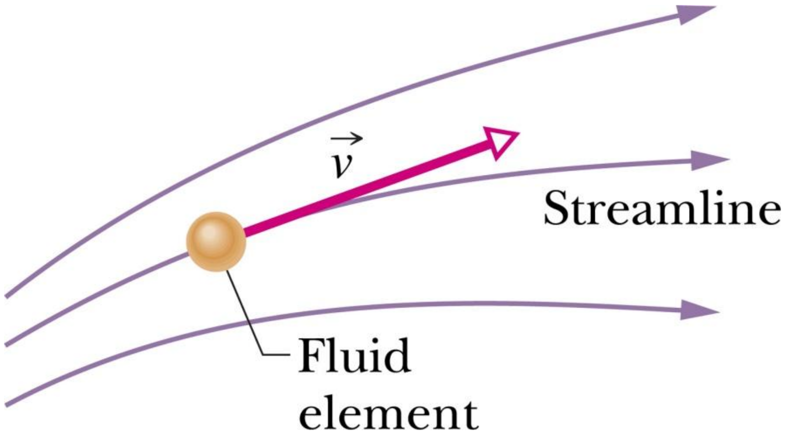
Ideal flow의 운동

turbulent flow

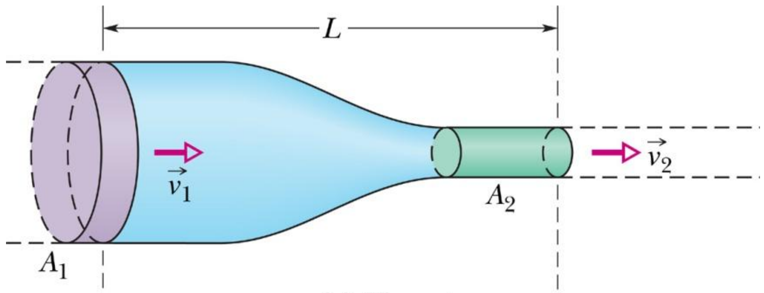
1. steady flow
2. incompressible flow
3. nonviscous flow
4. irrotational flow

streamline

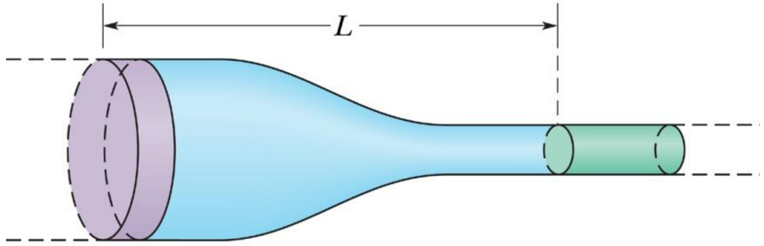




Continuity equation



(a) Time t



(b) Time $t + \Delta t$

$$\Delta V = A \Delta x = A v \Delta t$$

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

$$A_1 v_1 = A_2 v_2$$

continuity equation