Mekanika Fluida

Fluida dan Gaya Apung

Bagian 1

Defininisi suatu Fluida

- Suatu fluida adalah suatu materi yang bukan dalam keadaan padat dimana atom atom atau molekul molekulnya bebas bergerak diantara mereka walaupun dalam keadaan saling terikat, seperti pada suatu gas atau suatu likuida.

- Baik likuida dan gas keduanya adalah fluida karena keduanya dapat mengalir (benda alir) dan berubah bentuk

- Bila likuida memiliki volume tetap; gas tidak memiliki volume tetap.

Densitas dan Gaya Apung

- Konsentrasi materi yang membentuk suatu objek disebut sebagai **rapatan (densitas) massa**.

- **Rapatan massa**.diukur sebagai jumlah massa per satuan volume suatu substansi.

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

$$\text{rapatan massa} = \frac{\text{massa}}{\text{volume}}$$

Nilai Rapatan BeberapaSubstansi

Densities of Some Common Substances*

Substance	ρ (kg/m^3)
Hydrogen	0.0899
Helium	0.179
Steam (100°C)	0.598
Air	1.29
Oxygen	1.43
Carbon dioxide	1.98
Ethanol	0.806×10^3
Ice	0.917×10^3
Fresh water (4°C)	1.00×10^3
Sea water (15°C)	1.025×10^3
Iron	7.86×10^3
Mercury	13.6×10^3
Gold	19.3×10^3

*All densities are measured at 0°C and 1 atm unless otherwise noted.

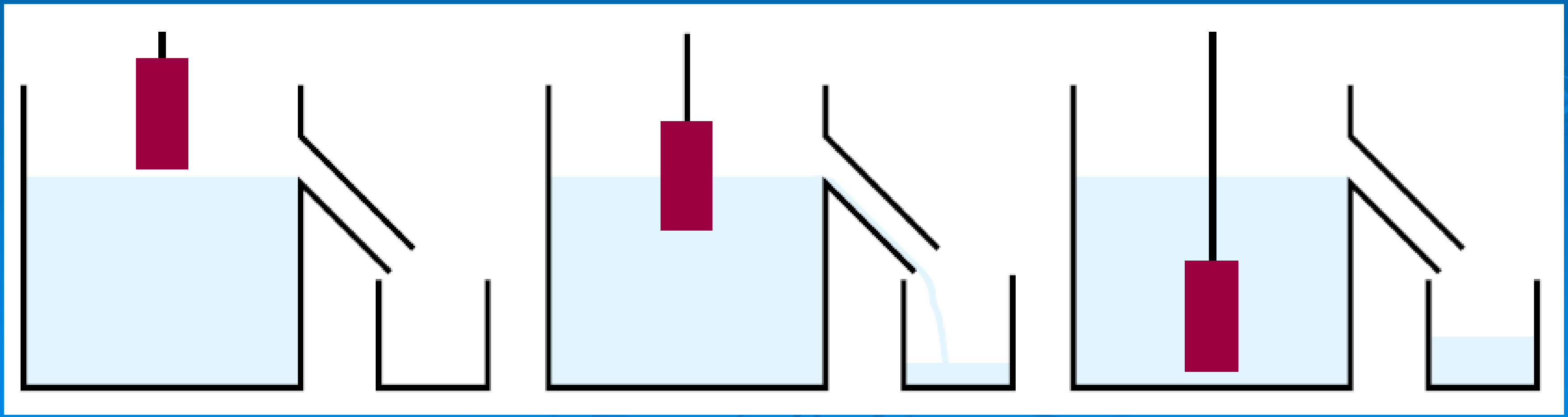
Densitas dan Gaya Apunh

- **Gaya apung** adalah suatu gaya ke atas yang dihasilkan oleh suatu likuida terhadap sebuah benda yang dimasukkan atau terapung pada likuida tadi.

- Gaya apung dapat menyebabkan objek tetap terapung.

Gaya Apung dan Prinsip Archimedes

- Sepotong batu bata bila dimasukkan ke dalam air akan menyebabkan air itu dipindahkan tempatnya dan akan mengisi wadah yang lebih kecil di samping..
- Berapakah volume air dalam wadah kecil tersebut ?
- Sama seperti volume batu bata itu!



Gaya Apungdan Archimedes' Principle

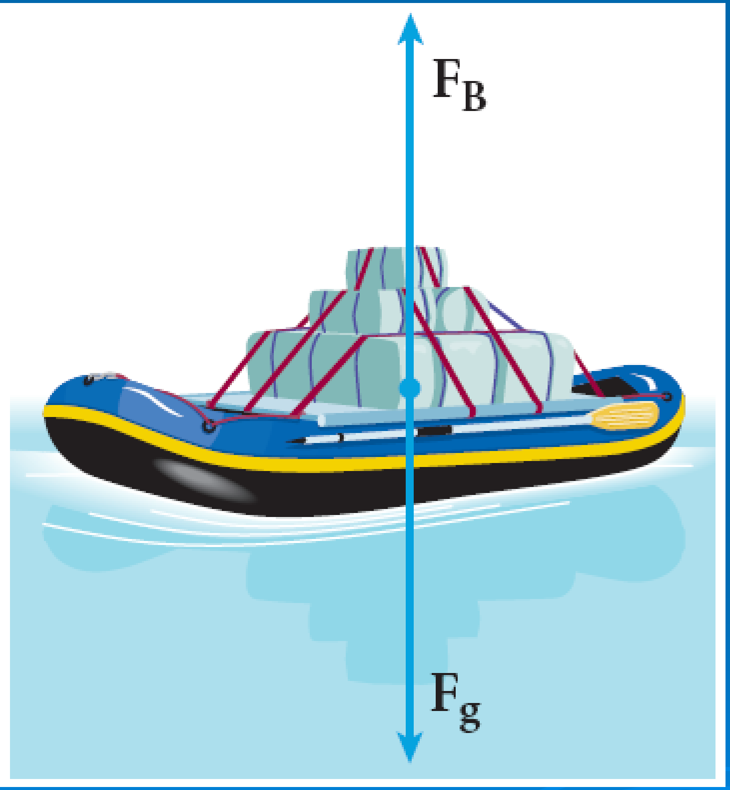
- Archimedes' principle describes the magnitude of a buoyant force.

- Archimedes' principle: *Any object completely or partially submerged in a fluid experiences an upward buoyant force equal in magnitude to the weight of the fluid displaced by the object.*

$$F_B = F_g \text{ (displaced fluid)} = m_f g$$

magnitude of buoyant force = weight of fluid displaced

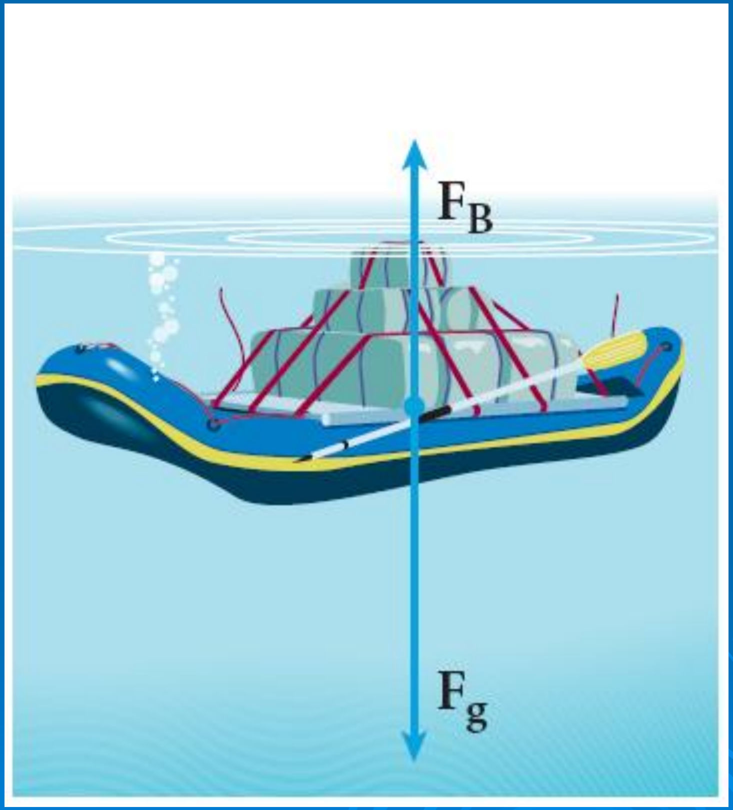
Buoyant Force



- The raft dan cargo are floating because their weight dan buoyant force are balanced.

Buoyant Force

- Now imagine a small hole is put in the raft.
- The raft dan cargo sink because their density is greater than the density of the water.
- As the volume of the raft decreases, the volume of the water displaced by the raft dan cargo also decreases, as does the magnitude of the buoyant force.



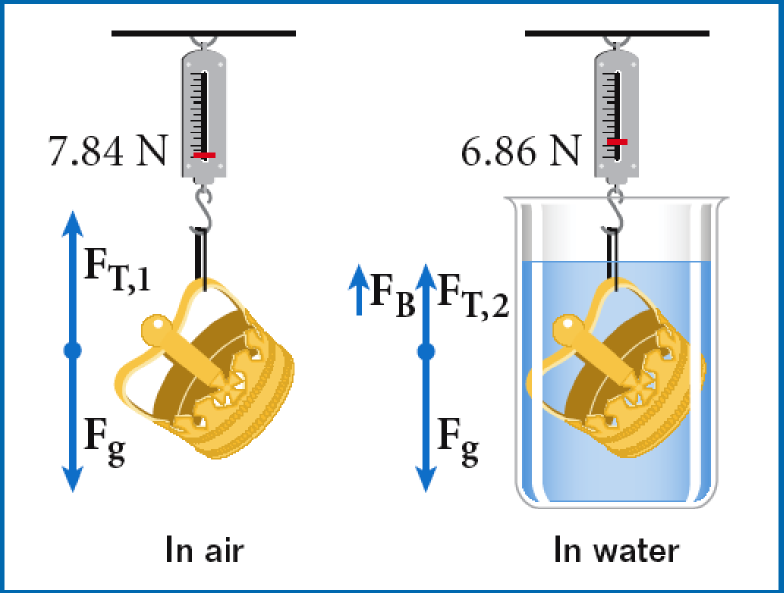
Buoyant Force

- For a floating object, the buoyant force equals the object's weight.
- The apparent weight of a submerged object depends on the density of the object.
- For an object with density ρ_O submerged in a fluid of density ρ_f, the buoyant force F_B obeys the following ratio:

$$\frac{F_g(object)}{F_B} = \frac{\rho_O}{\rho_f}$$

Example

- *A bargain hunter purchases a "gold" crown at a flea market. After she gets home, she hangs the crown from a scale dan finds its weight to be 7.84 N. She then weighs the crown while it is immersed in water, dan the scale reads 6.86 N. Is the crown made of pure gold? Explain.*



Solution

- Choose your equations:

$$F_g - F_B = \text{ apparent weight}$$

$$\frac{F_g}{F_B} = \frac{\rho_O}{\rho_f}$$

- Rearrange your equations:

$$F_B = F_g - (\text{apparent weight})$$

$$\rho_O = \frac{F_g}{F_B}\rho_f$$

Solution

- Plug dan Chug:

$$F_B = 7.84\ \text{N} - 6.86\ \text{N} = 0.98\ \text{N}$$

$$\rho_O = \frac{F_g}{F_B}\rho_f = \frac{7.84\ \text{N}}{0.98\ \text{N}}\left(1.00\times10^3\ \text{kg/m}^3\right)$$

$$\boxed{\rho_O = 8.0\times10^3\ \text{kg/m}^3}$$

- From the table in your book, the density of gold is 19.3×10^3 kg/m^3.
- Because 8.0×10^3 kg/m^3 $<$ 19.3×10^3 kg/m^3, the crown cannot be pure gold.

Your Turn I

- A piece of metal weighs 50.0 N in air dan 36.0 N in water dan 41.0 N in an unknown liquid. Find the densities of the following:
  - The metal
  - The unknown liquid
- A 2.8 kg rectangular air mattress is 2.00 m long dan 0.500 m wide dan 0.100 m thick. What mass can it support in water before sinking?
- A ferry boat is 4.0 m wide dan 6.0 m long. When a truck pulls onto it, the boat sinks 4.00 cm in the water. What is the weight of the truck?

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Fluid Pressure

Bagian 2

Pressure

- Deep sea divers wear atmospheric diving suits to resist the forces exerted by the water in the depths of the ocean.
- You experience this pressure when you dive to the bottom of a pool, drive up a mountain, or fly in a plane.

Pressure

- **Pressure** is the magnitude of the force on a surface per unit area.

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

$$\text{pressure} = \frac{\text{force}}{\text{area}}$$

- Pascal's principle states that pressure applied to a fluid in a closed container is transmitted equally to every point of the fluid dan to the walls of the container.

Pressure

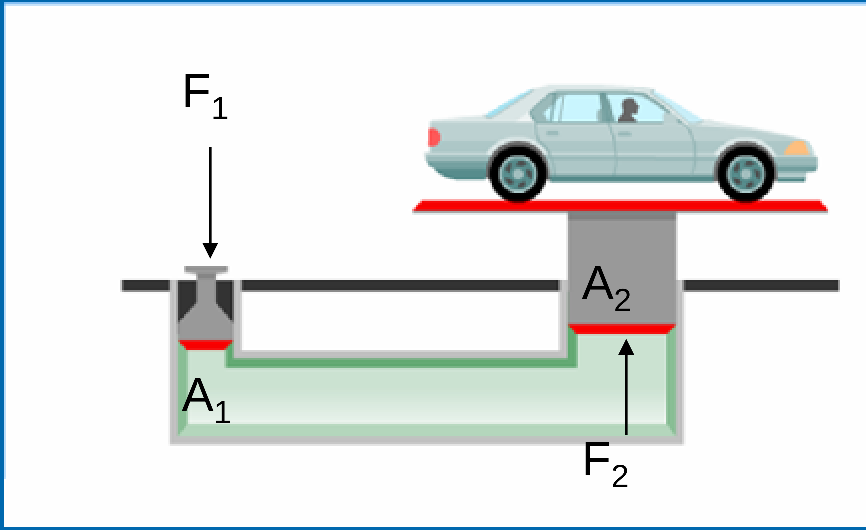
- The SI unit for pressure is the pascal, Pa.
- It is equal to 1 N/m^2.
- The pressure at sea level is about 1.01×10^5 Pa.
- This gives us another unit for pressure, the atmosphere, where 1 atm = 1.01×10^5 Pa

Pascal's Principle

- When you pump a bike tire, you apply force on the pump that in turn exerts a force on the air inside the tire.
- The air responds by pushing not only on the pump but also against the walls of the tire.
- As a result, the pressure increases by an equal amount throughout the tire.

Pascal's Principle

- A hydraulic lift uses Pascal's principle.
- A small force is applied (F_1) to a small piston of area (A_1) dan cause a pressure increase on the fluid.
- This increase in pressure (P_{inc}) is transmitted to the larger piston of area (A_2) dan the fluid exerts a force (F_2) on this piston.



$$P_{inc} = \frac{F_1}{A_1} = \frac{F_2}{A_2}$$

$$F_2 = F_1 \frac{A_2}{A_1}$$

Example

- The small piston of a hydraulic lift has an area of 0.20 m^2. A car weighing 1.20×10^4 N sits on a rack mounted on the large piston. The large piston has an area of 0.90 m^2. How much force must be applied to the small piston to support the car?

Solution

$$\frac{F_1}{A_1} = \frac{F_2}{A_2} \longrightarrow F_1 = F_2 \frac{A_1}{A_2}$$

- Plug dan Chug:
- $F_1 = (1.20 \times 10^4 \text{ N}) (0.20 \text{ m}^2 / 0.90 \text{ m}^2)$
- $F_1 = 2.7 \times 10^3 \text{ N}$

Your Turn II

- In a car lift, compressed air exerts a force on a piston with a radius of 5.00 cm. This pressure is transmitted to a second piston with a radius of 15.0 cm.
  - How large of a force must the air exert to lift a 1.33×10^4 N car?
- A person rides up a lift to a mountain top, but the person's ears fail to "pop". The radius of each ear drum is 0.40 cm. The pressure of the atmosphere drops from 10.10×10^5 Pa at the bottom to 0.998×10^5 Pa at the top.
  - What is the pressure difference between the inner dan outer ear at the top of the mountain?
  - What is the magnitude of the net force on each eardrum?

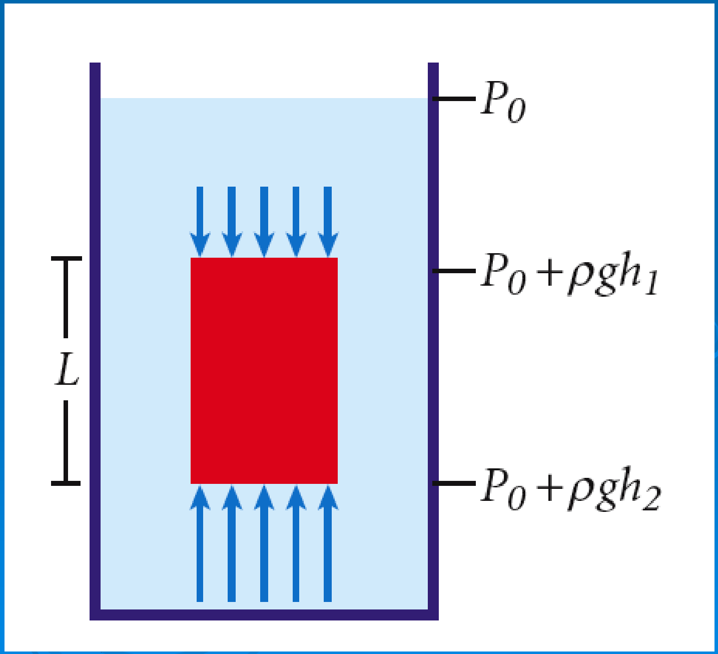
Pressure

- Pressure varies with depth in a fluid.

- The pressure in a fluid increases with depth.

$$P = P_0 + \rho g h$$

absolute pressure =
atmospheric pressure +
(density × free-fall acceleration × depth)



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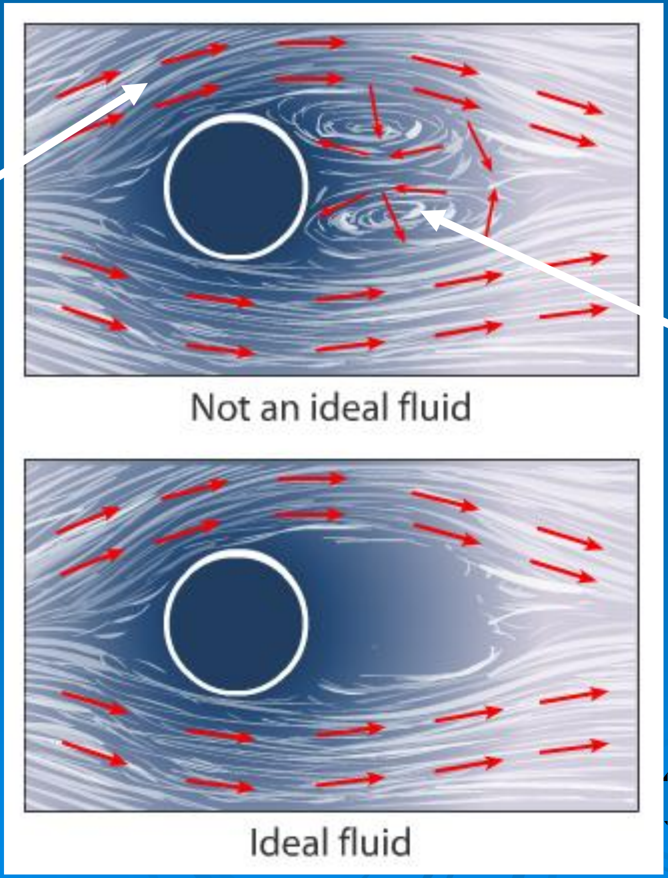
Fluida in Motion

Bagian 3

Fluid Flow

- Moving Fluida can exhibit *laminar* (smooth) flow or *turbulent* (irregular) flow.

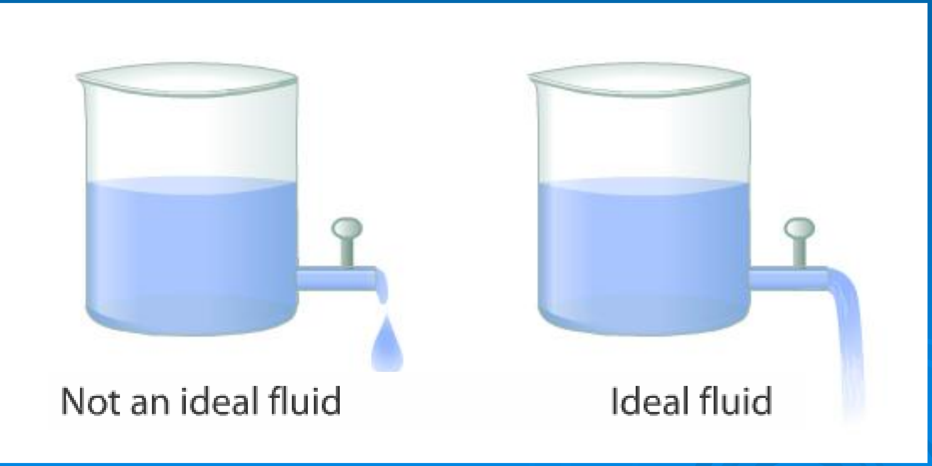
Laminar Flow

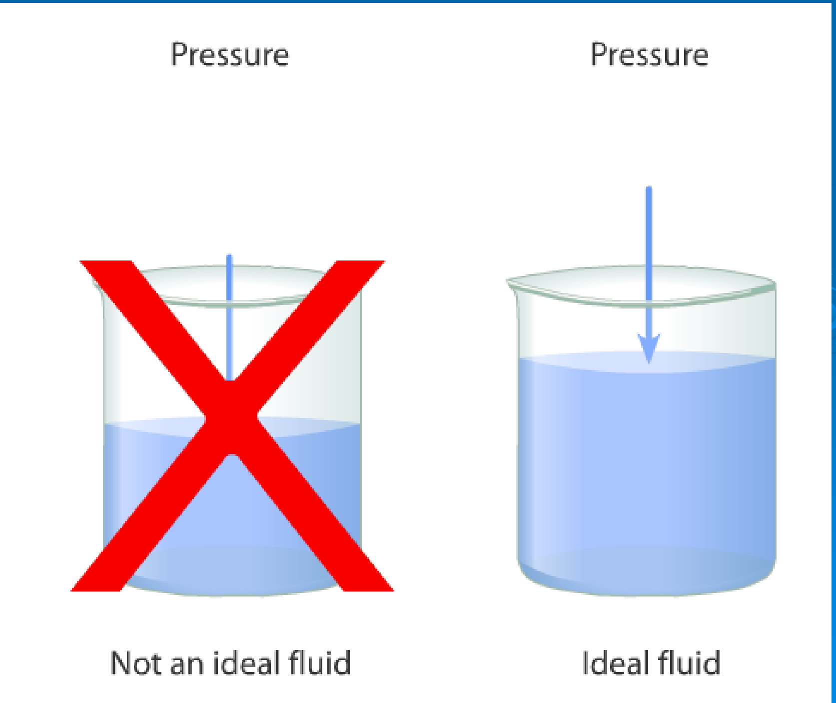


Turbulent Flow

Fluid Flow

- An **ideal fluid** is a fluid that has no internal friction or viscosity dan is incompressible.
- The ideal fluid model simplifies fluid-flow analysis



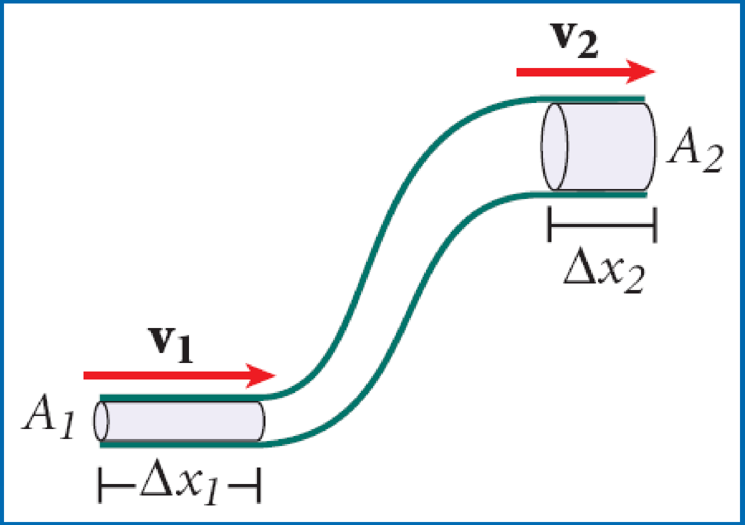


Fluid Flow

- No real fluid has all the properties of an ideal fluid, it helps to explain the properties of real Fluida.
- Viscosity refers to the amount of internal friction within a fluid. High viscosity equals a slow flow.
- Steady flow is when the pressure, viscosity, dan density at each point in the fluid are constant.

Principles of Fluid Flow

- The continuity equation results from conservation of mass.



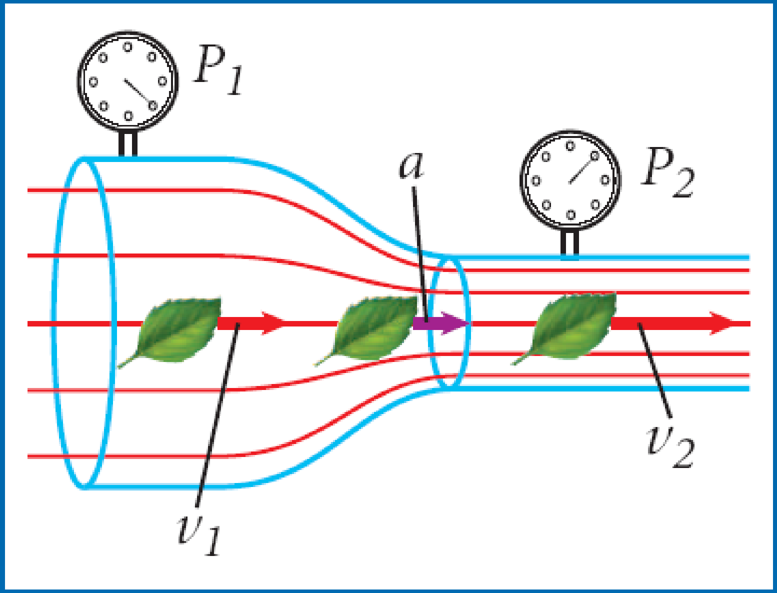
- Continuity equation:

$$A_1 v_1 = A_2 v_2$$

Area × speed in region 1 = area × speed in region 2

Principles of Fluid Flow

- The speed of fluid flow depends on cross-sectional area.
- Bernoulli's principle states that the pressure in a fluid decreases as the fluid's velocity increases.



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