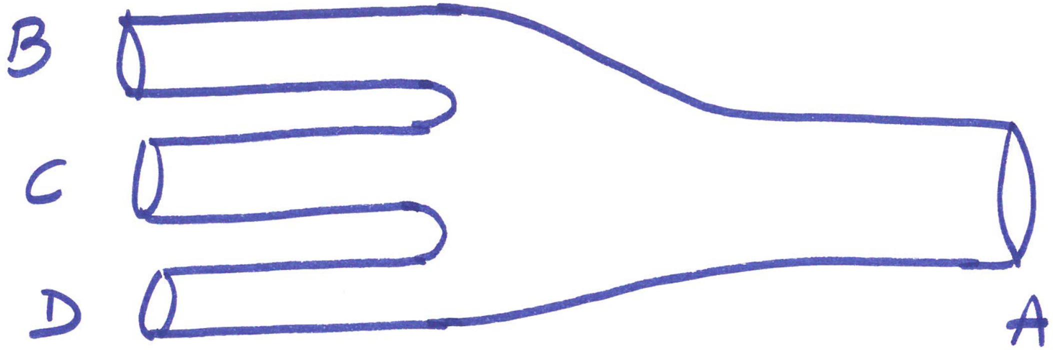
ESERCIZIO 1



$r_{B,C,D} = 0,5\ cm$
$r_A = 1\ cm$

$Q_B = 30\ l/min$
$Q_C = 25\ l/min$
$Q_D = 15\ l/min$

$Q_A = ?$
$v_A = ?$
$v_B = ?$

$$Q_A = Q_B + Q_C + Q_D = (30 + 25 + 15)\ \frac{l}{min} = 70\ l/min$$

$$v_A = \frac{Q_A}{S_A} = \frac{Q_A}{\pi r_A^2} = \frac{1,17 \cdot 10^{-3}\ m^3/s}{\pi \cdot (10^{-2}\ m)^2} = 3,71\ m/s$$

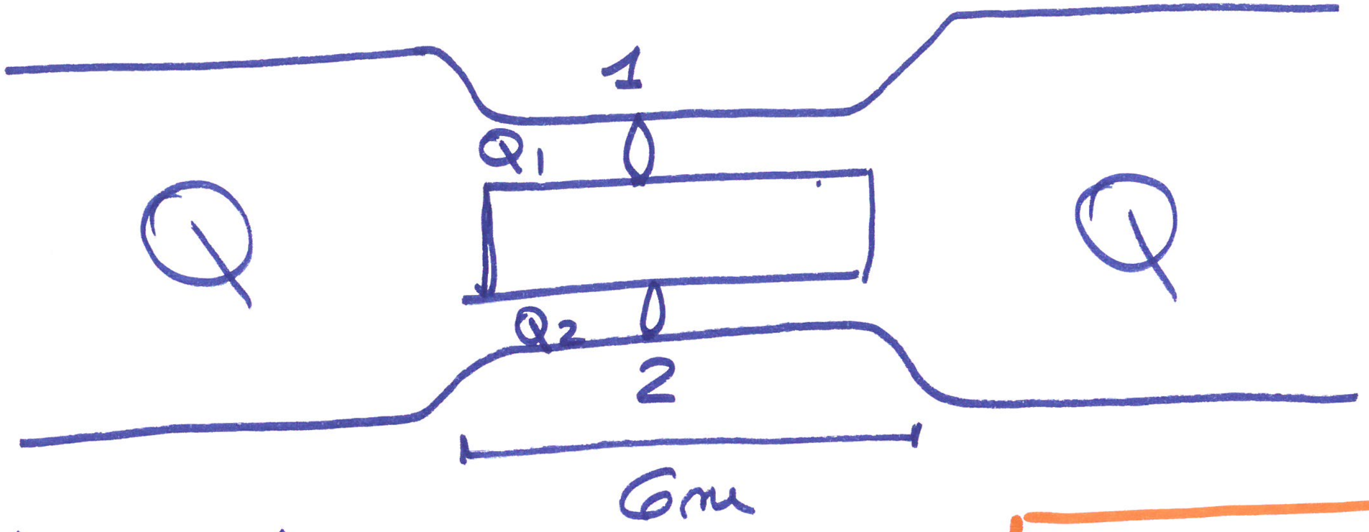
$$Q_A = v_A S_A$$

FATT. DI CONVERSIONE

$$70\ \frac{l}{min} = 70 \cdot \frac{10^{-3}}{60}\ \frac{m^3}{s} = 1,17 \cdot 10^{-3}\ \frac{m^3}{s}$$

$$1\ l = 1\ dm^3 = 10^{-3}\ m^3$$

ESERCIZIO 2.



DUE CONDOTTI IN PARALLELO

$\Delta P_1 = \Delta P_2$

$R_1 \neq R_2$

$r_1 = 4$ cm

$r_2 = 6$ cm

$\ell = 6$ m

$\eta = 1{,}7 \cdot 10^{-3}$ Pa·s

$Q = ?$

$\Delta P = 10^3$ Pa

$\Delta P = Q_1 R_1 \longrightarrow Q_1 = \frac{\Delta P}{R_1}$

$\Delta P = Q_2 R_2 \longrightarrow Q_2 = \frac{\Delta P}{R_2}$

$Q = Q_1 + Q_2$

$Q = \frac{\Delta P}{R_1} + \frac{\Delta P}{R_2}$

$Q = \Delta P \left(\frac{1}{R_1} + \frac{1}{R_2} \right)$

$$\Delta P = Q R_{eq} \rightarrow Q = \frac{\Delta P}{R_{eq}} \rightarrow \frac{\cancel{\Delta P}}{R_{eq}} = \cancel{\Delta P}\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$$

CONDOTTI IN PARALLELO

$$\boxed{\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}}$$

$$\frac{1}{R_{eq}} = \frac{R_2 + R_1}{R_1 R_2}$$

$$\boxed{R_{eq} = \frac{R_1 R_2}{R_2 + R_1}}$$

$$R_{eq} < R_1$$

$$R_{eq} < R_2$$

$$Q = \Delta P \left(\frac{1}{R_1} + \frac{1}{R_2} \right) \quad (*)$$

$$R = \frac{8 \eta l}{\pi r^4}$$

$$R_1 = \frac{8 \eta l}{\pi r_1^4} \qquad R_2 = \frac{8 \eta l}{\pi r_2^4}$$

$$Q = \Delta P \cdot \left(\frac{\pi r_1^4}{8 \eta l} + \frac{\pi r_2^4}{8 \eta l} \right)$$

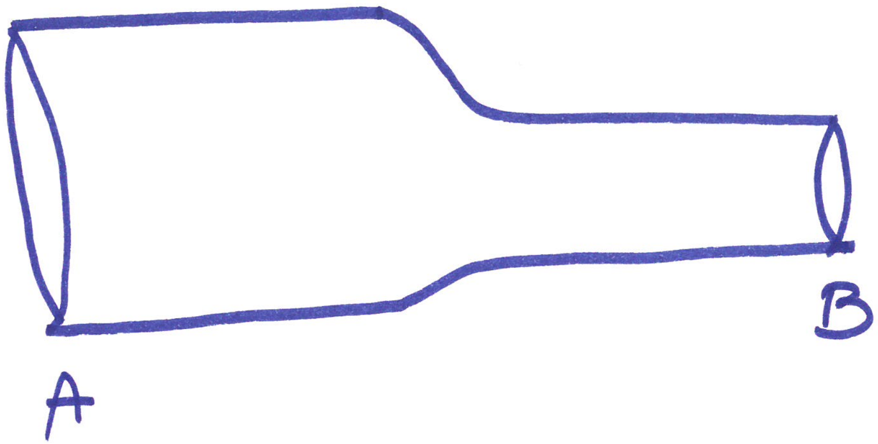
$$= \frac{\Delta P \cdot \pi}{8 \eta l} \left(r_1^4 + r_2^4 \right)$$

$$= \frac{(10^3 \cancel{Pa}) \cdot \pi}{8 (1{,}7 \cdot 10^{-3} \cancel{Pa} \cdot s) \cdot (6 \cancel{m})} \cdot \left[(4 \cdot 10^{-2} m)^4 + (6 \cdot 10^{-2} m)^4 \right]$$

$$(4^4 + 6^4) \cdot 10^{-8} m^{\cancel{4}\,3}$$

$$= 0{,}6 \; m^3/s$$

CONDOTTI IN SERIE



$$Q_A = Q_B = Q$$

$$\Delta P_A = R_A Q$$

$$\Delta P_B = R_B Q$$

$$\Delta P = \Delta P_A + \Delta P_B = R_A Q + R_B Q = (R_A + R_B) Q$$

CONDOTTI IN SERIE

$$R_{eq} = R_A + R_B$$

UNITA' di MISURA

$$R = \frac{\Delta P}{Q} = \frac{Pa}{\frac{m^3}{s}} = \frac{Pa \cdot s}{m^3} = \frac{\frac{N}{m^2} \cdot s}{m^3} = \frac{N \cdot s}{m^5}$$

Condotto di lunghezza $\ell = 8$ cm e raggio

$r = 0{,}75$ mm $\quad Q = 0{,}5\ cm^3/s = 0{,}5 \cdot 10^{-6}\ \frac{m^3}{s}$

$\Delta P = 1{,}2\ kN/m^2$

$\eta = ?$

$$R = \frac{8\eta\ell}{\pi r^4} \qquad \Delta P = RQ \Rightarrow \Delta P = \frac{8\eta\ell}{\pi r^4} \cdot Q$$

$$\eta = \frac{\Delta P \cdot \pi r^4}{8 \ell Q} = \frac{(1{,}2 \cdot 10^3\ \frac{N}{m^2}) \cdot \pi \cdot (0{,}75 \cdot 10^{-3}\ m)^4}{8 \cdot (8 \cdot 10^{-2}\ m) \cdot (0{,}5 \cdot 10^{-6}\ \frac{m^3}{s})} \quad 10^{-1}$$

Pa

$$= 3{,}7 \cdot 10^{-2} \cdot 10^{-1} = 3{,}7 \cdot 10^{-3}\ Pa \cdot s$$

Arteria il cui raggio diminuisce del 10%. quale aumento di ΔP si deve applicare per mantenere Q costante?

r_1 = RAGGIO INIZIALE

$r_2 = 0{,}9\, r_1$ RAGGIO FINALE

$$\Delta P_1 = R_1 Q \longrightarrow \Delta P_1 = \frac{8\eta l}{\pi r_1^4} \cdot Q \longrightarrow Q = \frac{\Delta P_1 \cdot \pi r_1^4}{8\eta l}$$

$$\Delta P_2 = R_2 Q \longrightarrow \Delta P_2 = \frac{8\eta l}{\pi r_2^4} Q \longrightarrow Q = \frac{\Delta P_2 \cdot \pi r_2^4}{8\eta l}$$

$$\frac{\Delta P_1 \cdot \pi r_1^4}{8\eta l} = \frac{\Delta P_2\, \pi r_2^4}{8\eta l} \longrightarrow \Delta P_1 \cdot r_1^4 = \Delta P_2\, r_2^4$$

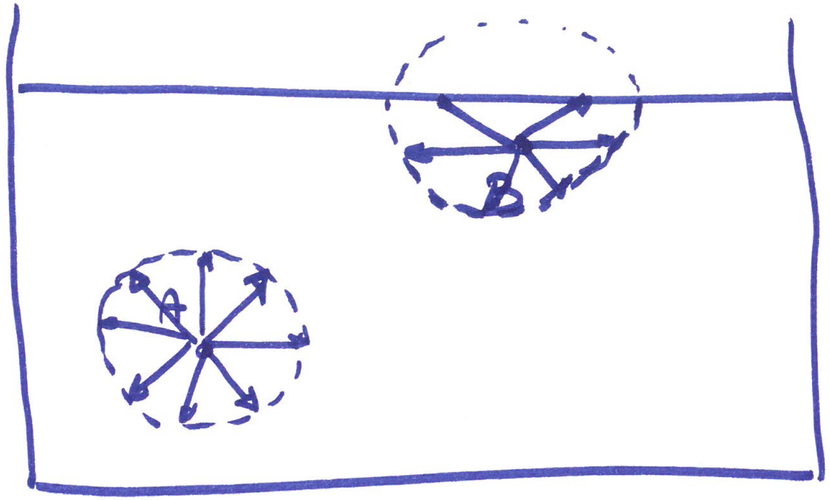
$$\Delta P_2 = \Delta P_1 \cdot \frac{r_1^4}{r_2^4} = \Delta P_1 \cdot \frac{r_1^4}{(0{,}9 \cdot r_1)^4} = \Delta P_1 \cdot \frac{r_1^4}{0{,}9^4 \cdot r_1^4}$$

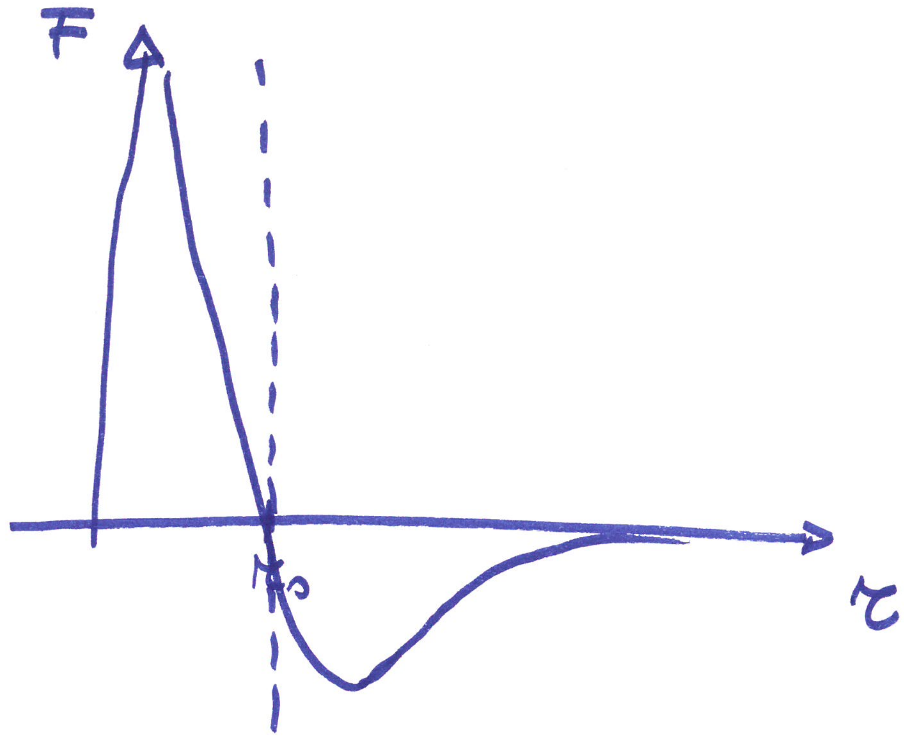
$$\Delta P_2 = \Delta P_1 \cdot \frac{1}{0{,}9^4} = \Delta P_1 \cdot 1{,}52$$

$$\Delta P_2 = \Delta P_1 \cdot 1{,}52$$

ΔP_2 aumenta del 52 %

TENSIONE SUPERFICIALE





FORZE di COESIONE

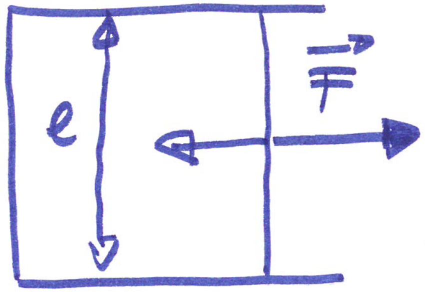
↓

TENSIONE SUPERFICIALE

$$\vec{\tau} = \frac{d\vec{F}_\tau}{dl} \quad \left[\frac{N}{m}\right]$$ forza per unità di lunghezza

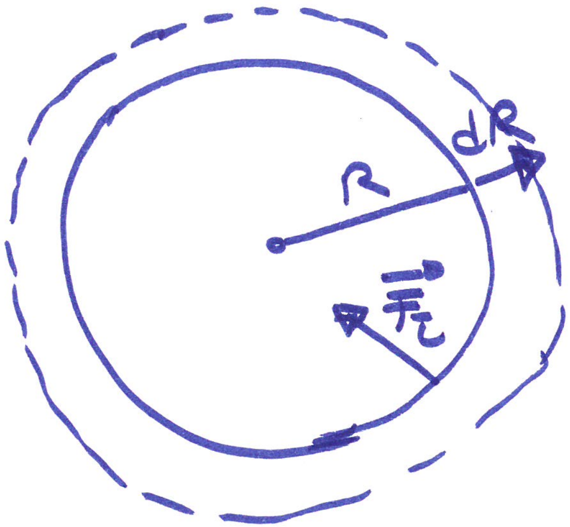
$r < r_0$ F. REPULSIVA

$r > r_0$ F. ATTRATTIVA



$$\tau = \frac{F_\tau}{2e}$$

LAMINA



$$dL = \vec{F_\tau} \cdot \vec{dR} = F_\tau \, dR \, \underbrace{\cos \pi}_{-1}$$

$$= -F_\tau \cdot dR = -\tau \cdot 2\pi R \cdot dR$$

$$\frac{dF_\tau}{de} = \tau \rightarrow \tau = F_\tau \cdot e$$

$$dL = -\tau \cdot \underbrace{2\pi R \, dR} = -\tau \, dS$$

$$S = \pi R^2 \quad dS = \pi 2R \cdot dR$$

$$dL = -\tau \, dS$$

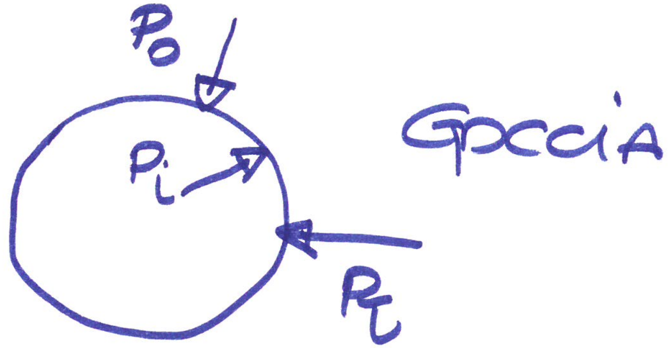
$$L = -\Delta U$$

$$dL = -dU$$

$$-dU = -\tau \, dS$$

$$\boxed{\tau = \frac{dU}{dS}} \quad \left[\frac{J}{m^2}\right]$$

LEGGE di LAPLACE



$$P_\tau = \frac{2\tau}{R}$$

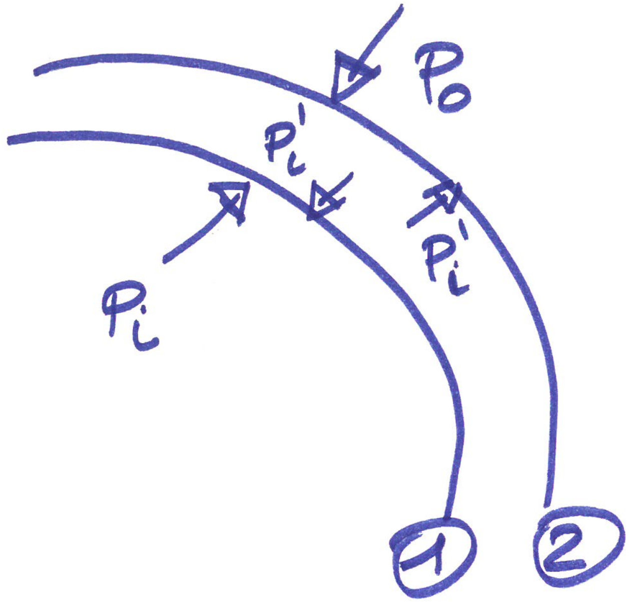
SUPERFICI CURVE

[redacted]

$$P_i = P_\tau + P_o$$

$$P_\tau = \boxed{P_i - P_o = \frac{2\tau}{R}}$$

BOLLA di SAPONE



$$① \quad P_i - P_i' = \frac{2\tau}{R}$$

$$② \quad P_i' - P_o = \frac{2\tau}{R}$$

R ~ lo stesso poiché' variazione e' infinitesima

$$① + ② \quad P_i - P_i' + P_i' - P_o = \frac{2\tau}{R} + \frac{2\tau}{R}$$

$$P_i - P_o = \frac{4\tau}{R}$$