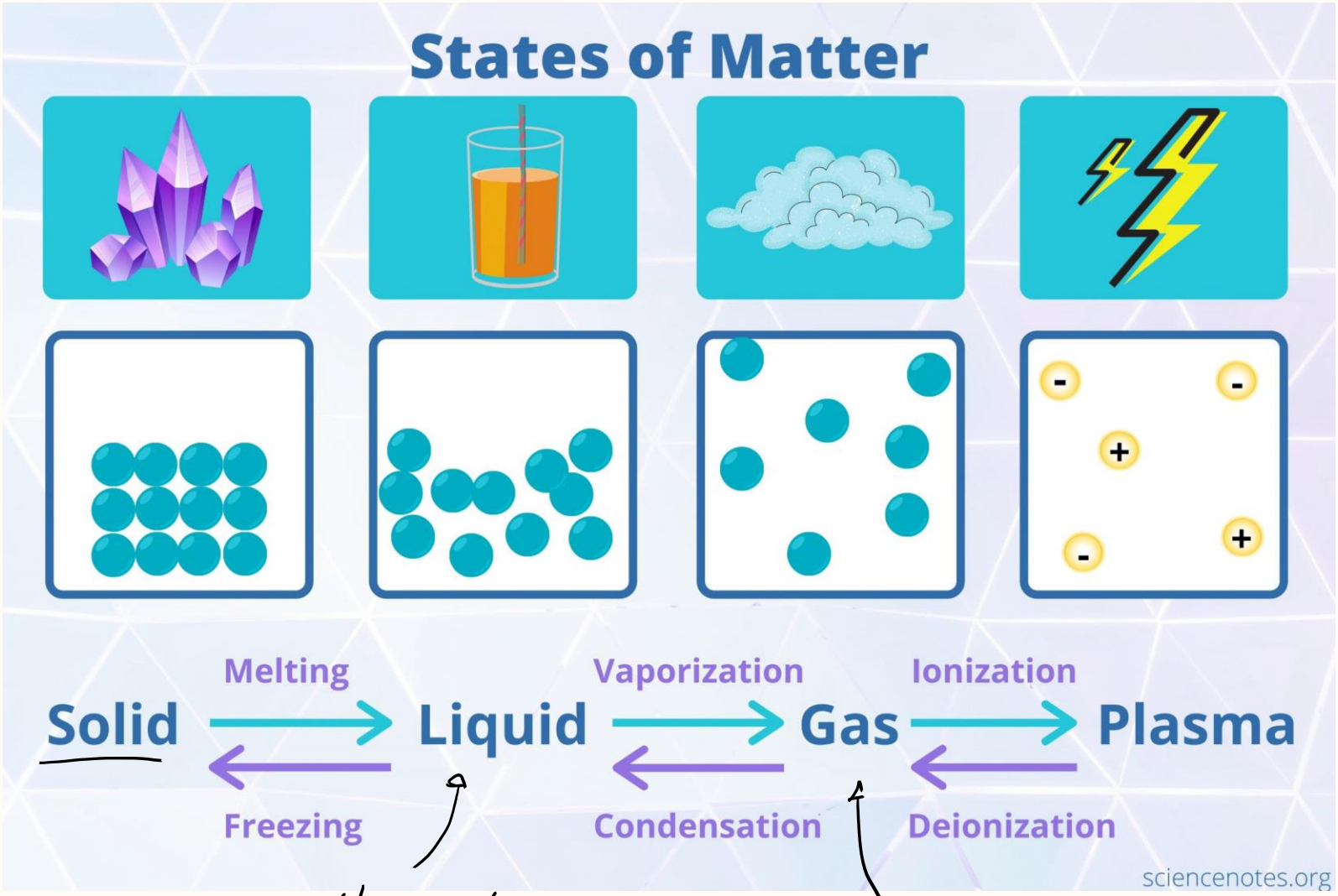
FYS1001
Innføring i fysikk

Lasse Clausen

07.02.2021

Fluidmekanikk



kan ikke trykkes sammen (inkompressibel)

kan trykkes sammen (kompressibel)

Massetetthet

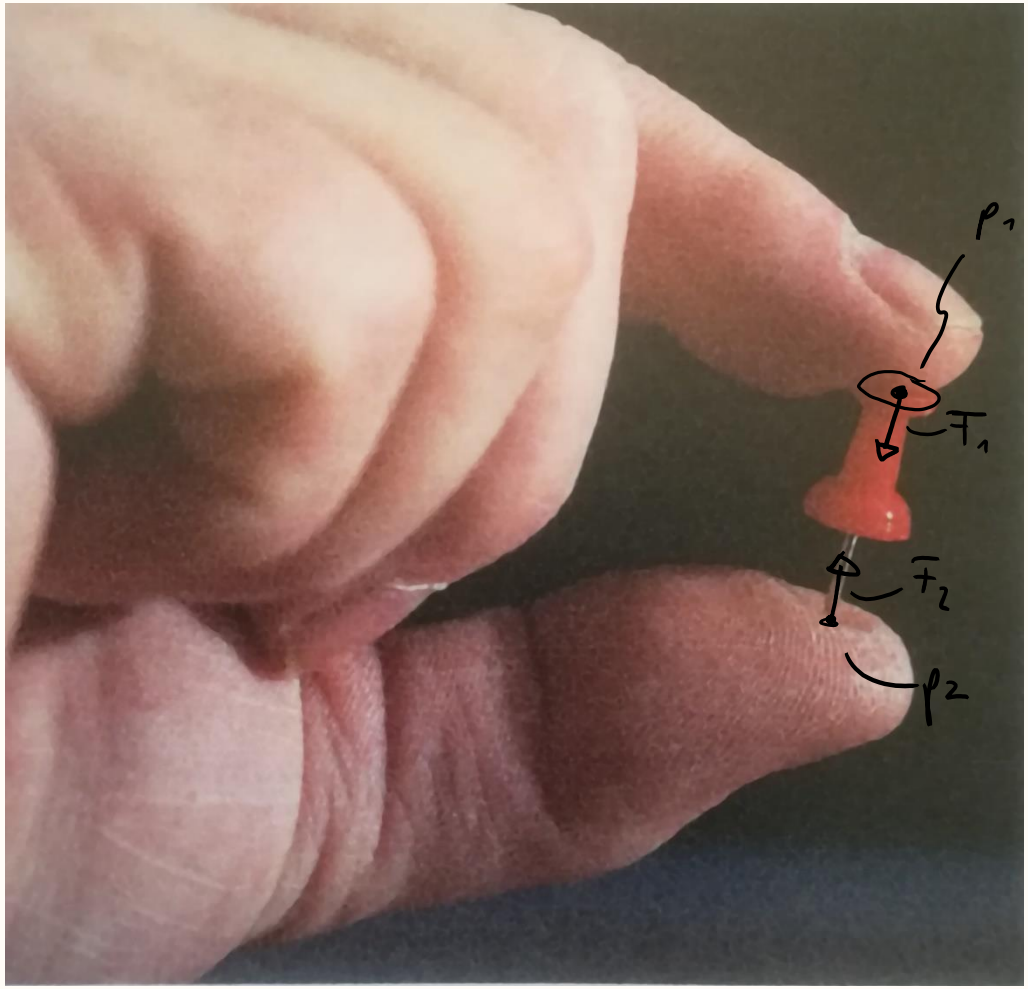
masse tetthet: $\rho = \frac{m}{V}$ $\quad [\rho] = \frac{kg}{m^3}$

$\rho_{Luft} = 1{,}3 \ kg/m^3$

$\rho_{vann} = 1{,}0 \cdot 10^3 \ kg/m^3$

$\rho_{jord} \sim 5{,}0 \cdot 10^3 \ kg/m^3$

Trykk



hvis tegnestiften er i ro:

Newton 1. lov: $\sum F = 0$

trykk: kraft per areal

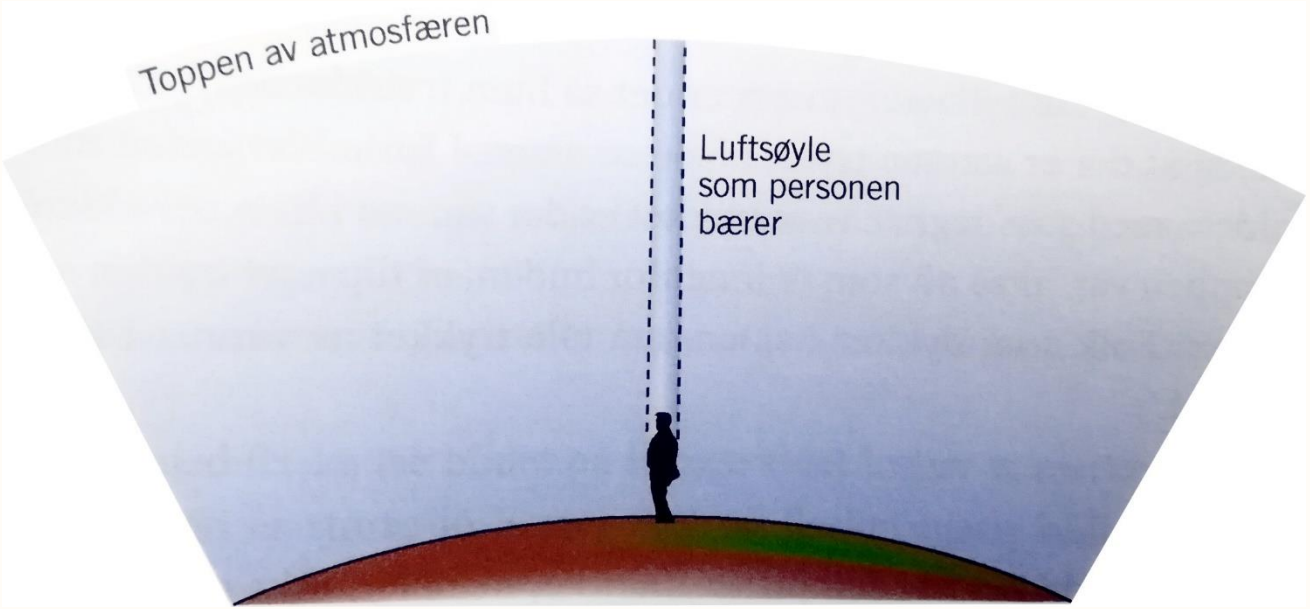
$$p = \frac{F}{A} \qquad [p] = \frac{N}{m^2} = Pa$$

$$F_1 - F_2 = 0$$

$$F_1 = F_2$$

$$p_1 = \frac{F_1}{A_1} \qquad p_2 = \frac{F_2}{A_2} = \frac{F_1}{A_2}$$

Lufttrykk



$p_0 \approx 101\ kPa = 1 atm$

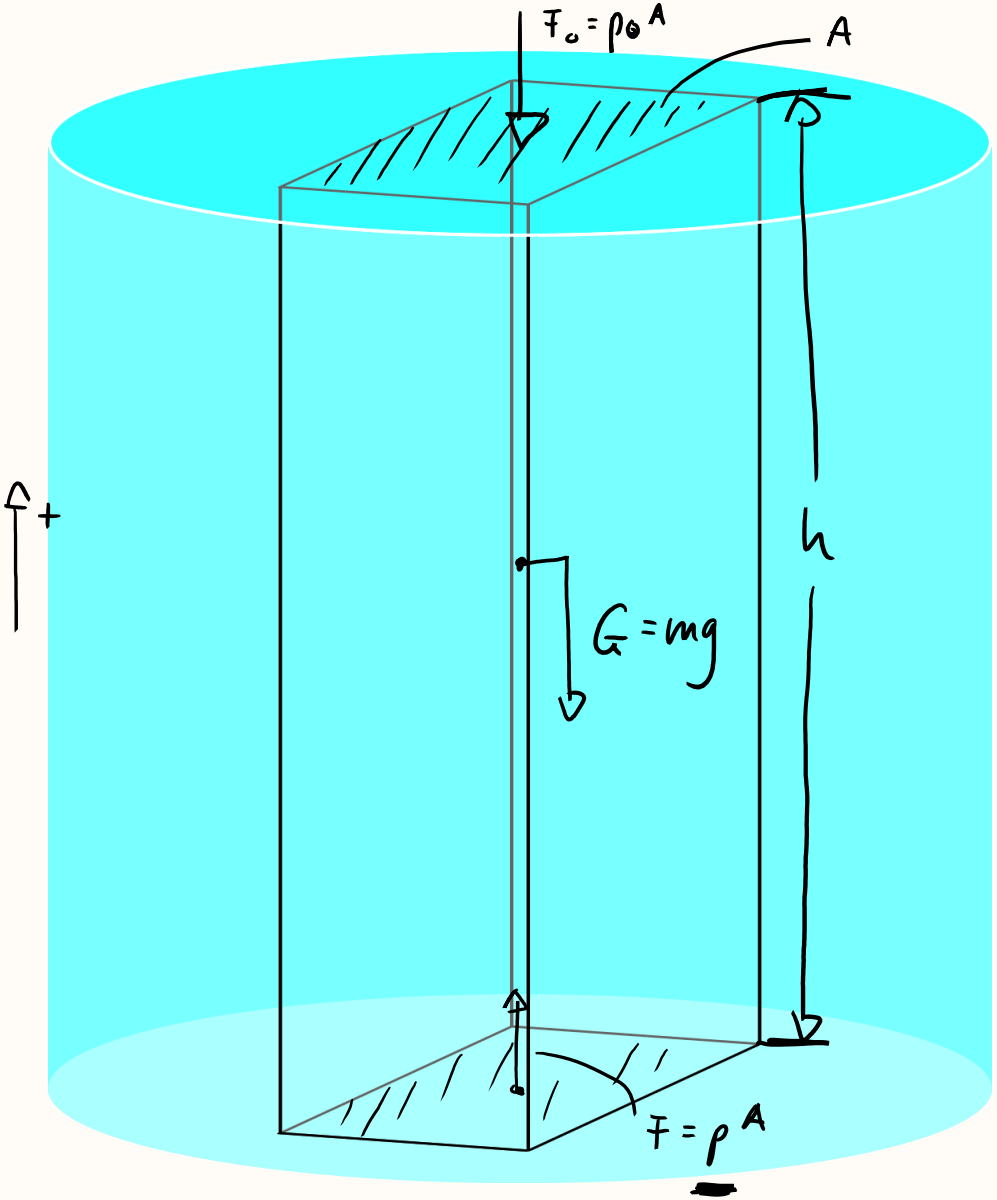
vekt per $1m^2$

$$p_0 = \frac{F}{A} \rightsquigarrow F = p_0 A = 101 \cdot 10^3\ N$$

$$\rightsquigarrow F = G = mg \rightsquigarrow m = \frac{G}{g}$$

$$m = \frac{100 \cdot 10^3\ N}{10\ m/s^2} \sim 10\,000 kg$$

Hydrostatisk trykk



statisk: $\sum F = 0$

$$-F_0 - G + F = 0$$

$$pA = p_0 A + mg$$

$$p = p_0 + \frac{mg}{A}$$

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

$m = \rho V$

$m = \rho Ah$

$$p = p_0 + \frac{\rho Ahg}{A}$$

$$\rightsquigarrow p = p_0 + \rho hg$$

Hydrostatisk trykk

$p = p_0 + \rho g h$

dobbelt så stort trykk: $p = 2p_0$

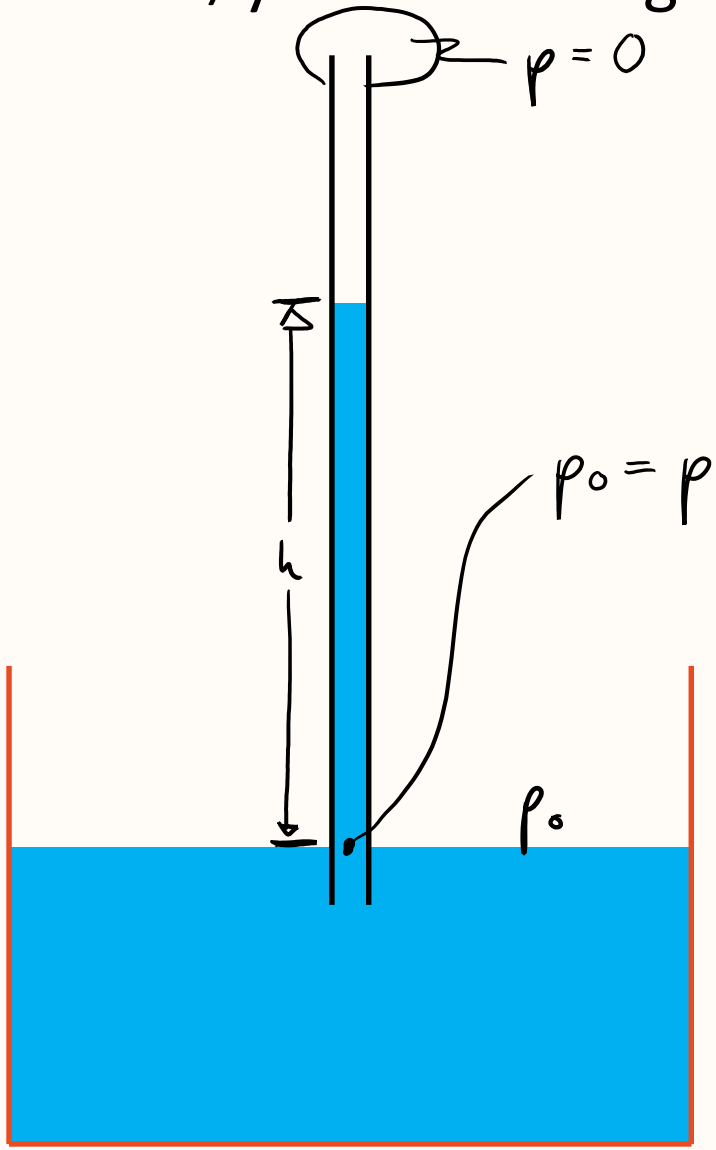
$2p_0 = p_0 + \rho g h$

$p_0 = \rho g h \rightsquigarrow h = \frac{p_0}{\rho g} = \frac{100 \cdot 10^3 \text{ Pa}}{1 \cdot 10^3 \text{ kg/m}^3 \cdot 10 \text{ m/s}^2}$

$h = 10\text{m}$

Sugerør

Hvor høyt kan noe suges opp med et sugerør?



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

$$h = \frac{p_0}{\rho g} = 10\,\text{m}$$

Men...


CANDIDE
The tallest trees in the world
Hyperion
116m
Centurion
100m
General Sherman
84m
Karri Tree
73m
Douglas Fir
67m
Oak Tree
35m
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Tall-ish human
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There's always a Dave
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Tasmania, Australia
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Coast redwood
(Sequoia sempervirens)
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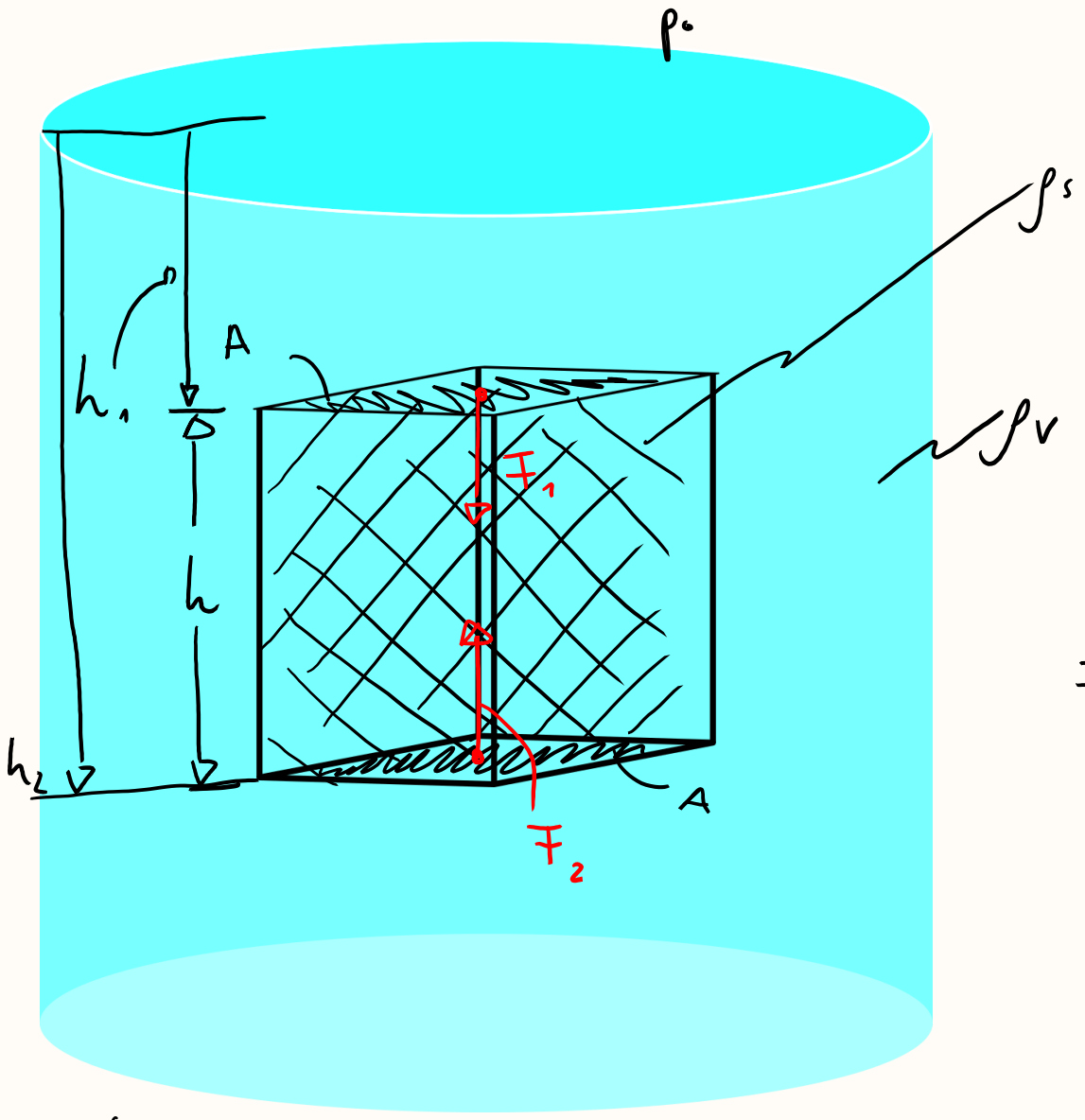
Redwood National Park, California
candidegardening.com

Oppdrift



$$F_1 = p_1 A = (p_0 + \rho_V g h_1) A$$

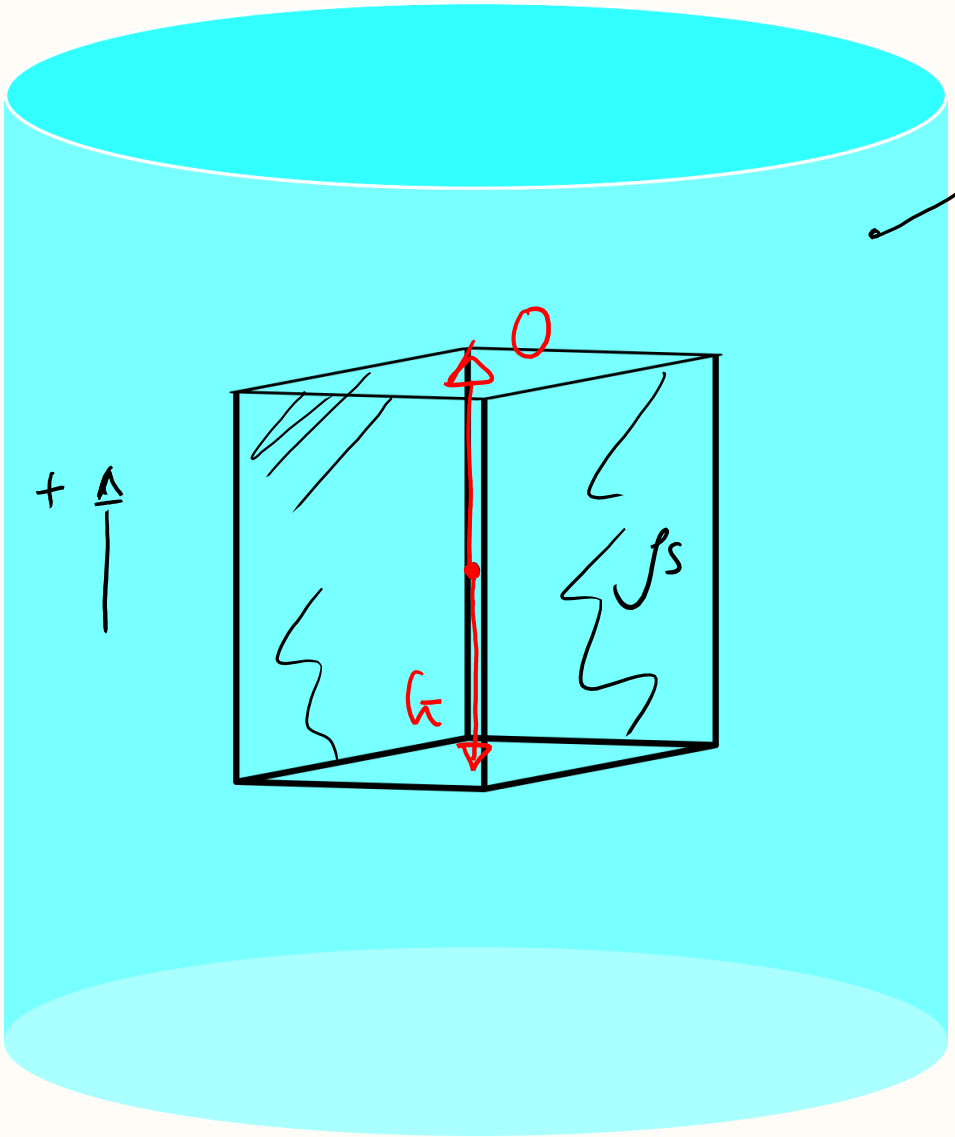
$$F_2 = p_2 A = (p_0 + \rho_V g h_2) A$$

$$F_2 - F_1 = (p_0 + \rho_V g h_2) A - (p_0 + \rho_V g h_1) A$$

$$= \rho_V g A (h_2 - h_1)$$

$$F_2 - F_1 = \rho_V g A h = \rho_V g V$$

Oppdrift



Oppdrift $O = \rho_v V g$

ρ_v $G = mg = \rho_s V g$

$\sum F = O - G$

$= \rho_v V g - \rho_s V g$

$= (\rho_v - \rho_s) V g$

hvis $\rho_s > \rho_v$
objektet synker

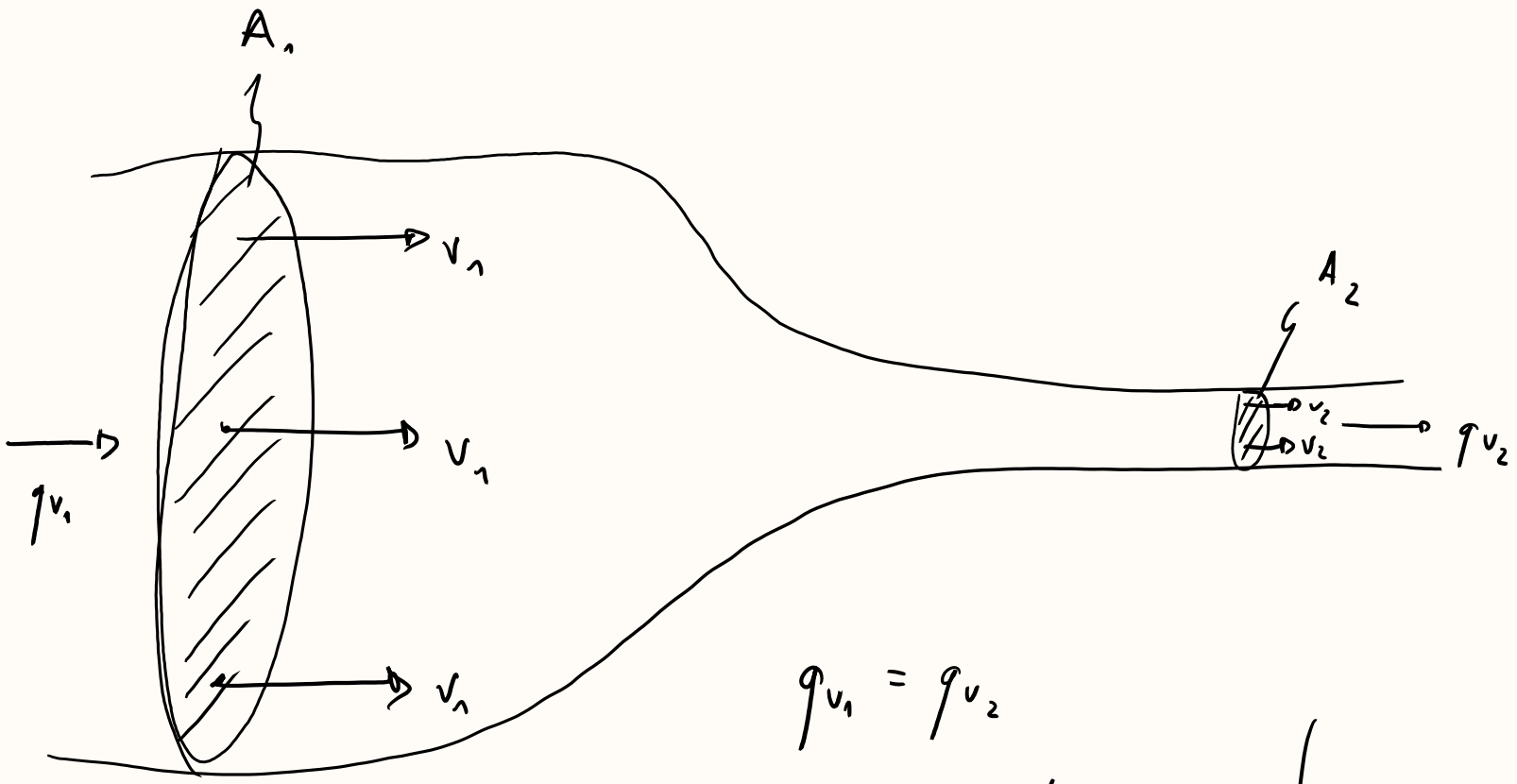
hvis $\rho_s < \rho_v$
objektet flyter

Fluidstrøm

volumstrøm : $q_v = \frac{V}{t}$

massestrøm : $q_m = \frac{m}{t}$

Kontinuitetslikning

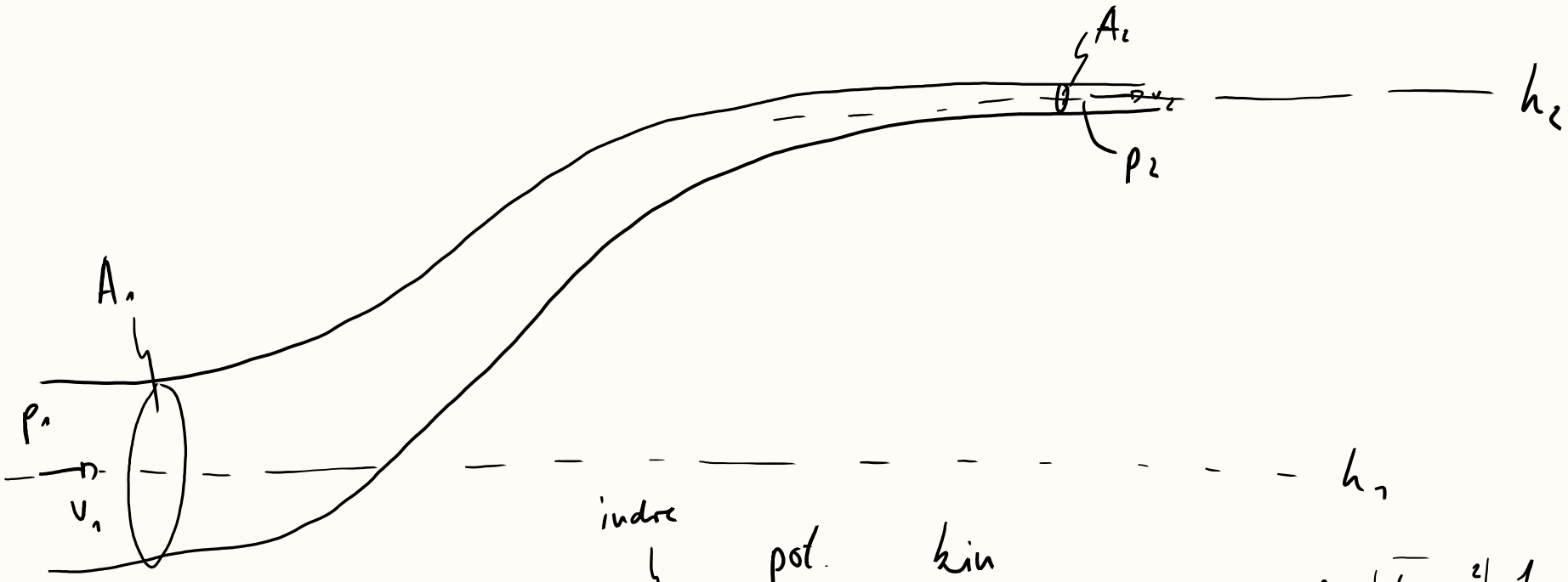


$$\rho v_1 = \rho v_2$$

$$\frac{V_1}{t} = A_1 v_1 = \frac{V_2}{t} = A_2 v_2 \quad \Big| \quad \underline{A_1 v_1 = A_2 v_2}$$

$$\Rightarrow v_2 = \frac{A_1}{A_2} v_1$$

Bernoulli-likning



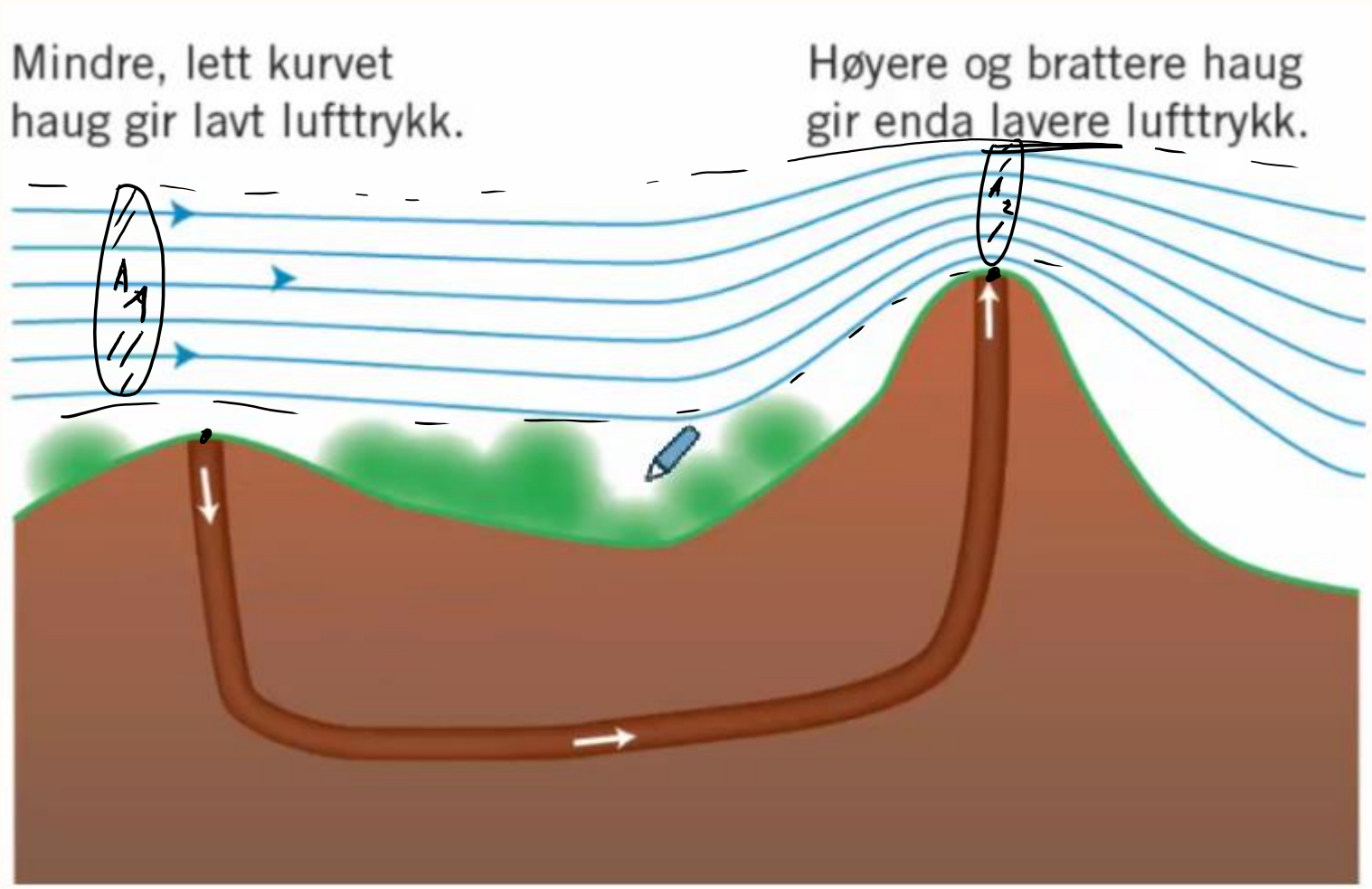
indre pot. kin

$$p_1 + \rho g h_1 + \frac{1}{2}\rho v_1^2 = p_2 + \rho g h_2 + \frac{1}{2}\rho v_2^2$$

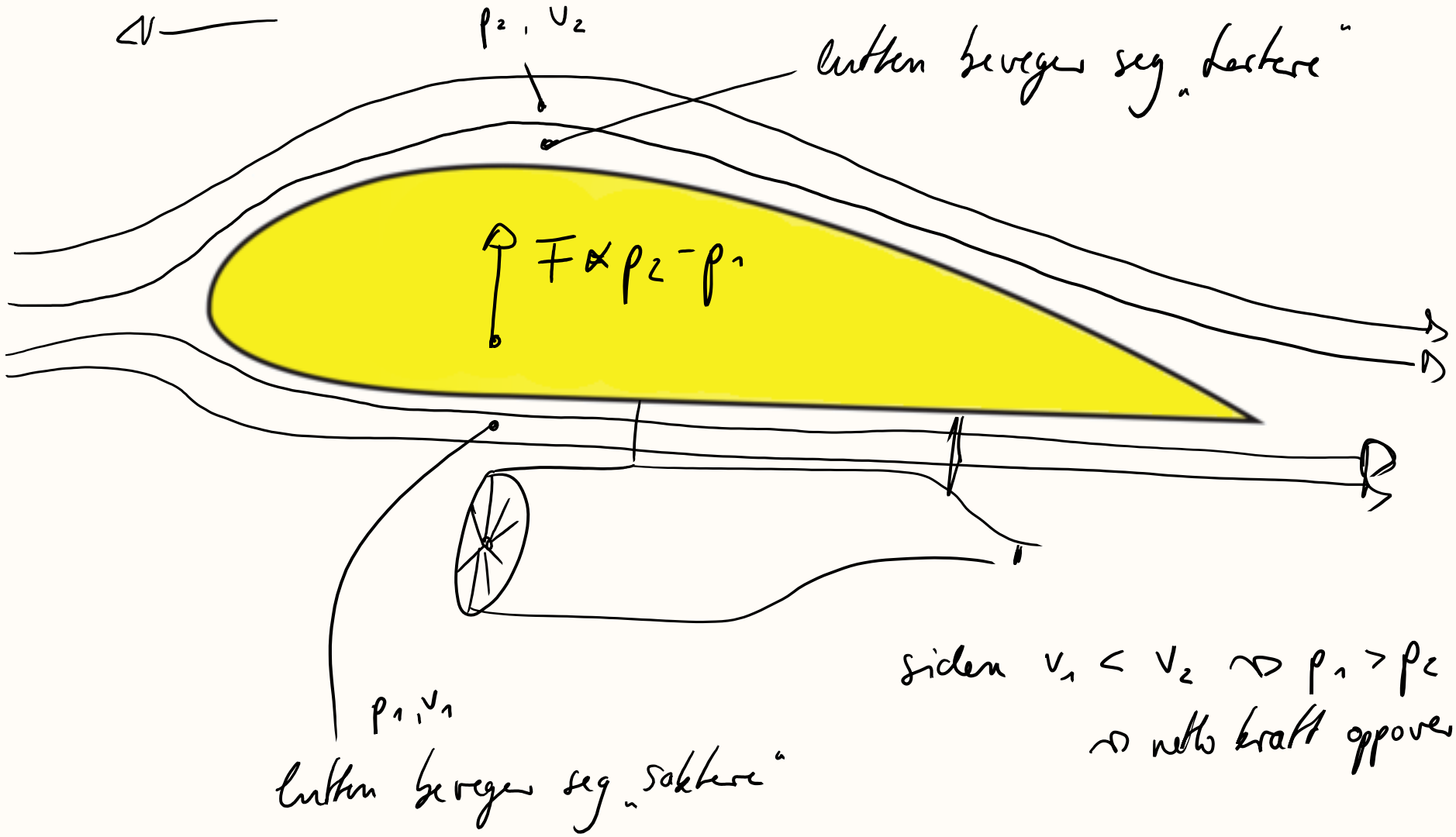
totale energi

$$\frac{1}{2}\rho v^2 = \left|\frac{1}{2}mv^2\right| \frac{1}{V}$$

Bernoulli in action



Bernoulli in action v2.0



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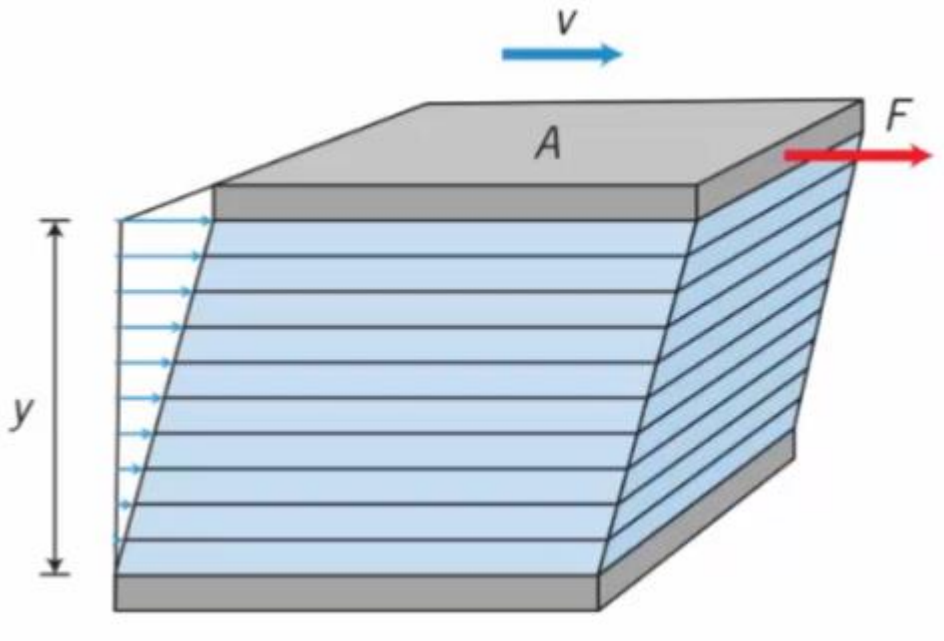
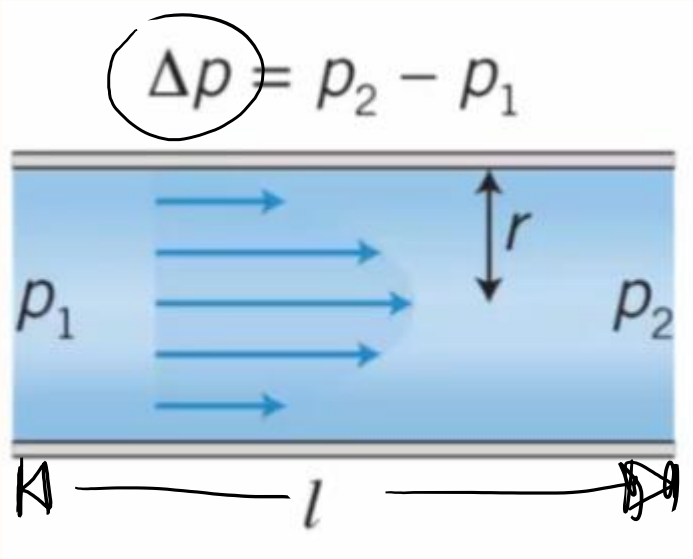
Viskositet



viskositet η

	T/°C	η/Pas
Hydrogen	20	$8{,}4 \cdot 10^{-6}$
Luft	0	$17 \cdot 10^{-6}$
	20	$18 \cdot 10^{-6}$
	100	$22 \cdot 10^{-6}$
Etanol	20	0,00012
Vann	0	0,0018
	20	0,0010
	100	0,00028
Blod	37	0,0025
Smøreolje	0	5,3
	20	0,99
	100	0,017
Glass	400	10^{12}

Viskøs veske i et rør

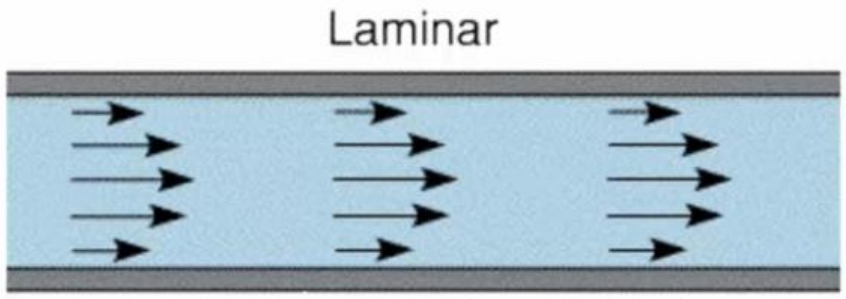


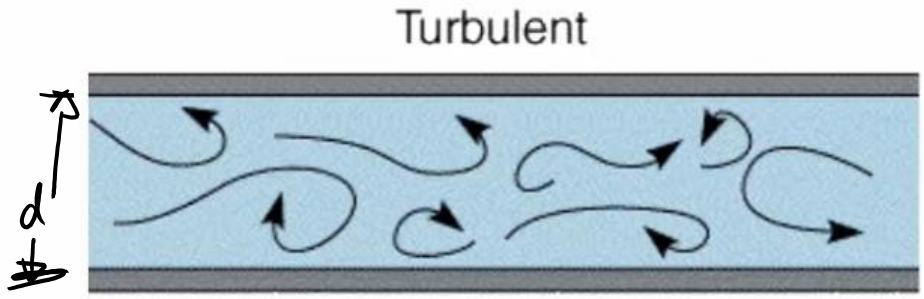
Hagen - Poiseuille - likning

$$q_v = \frac{\pi r^4 \Delta p}{8 \eta l} \rightarrow \eta = \frac{\pi r^4 \Delta p}{8 q_v l}$$

$$[\eta] = \frac{m^4 \, Pa}{\frac{m^3}{s} \, m} = Pa \, s$$

Reynoldstall



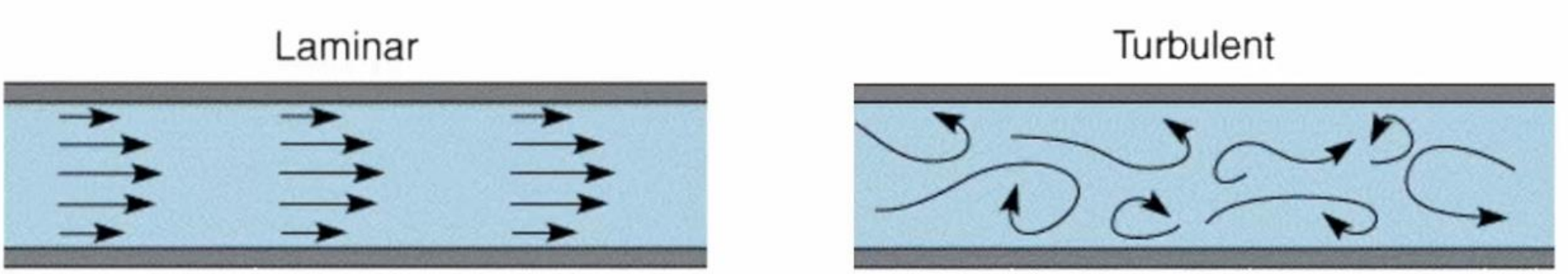


$$Re = \frac{\rho v d}{\eta}$$

laminar när $Re \leq 2000$

turbulent när $Re > 3000$

Reynoldstall



laminar
Re low
v low

turbulent

v stor

Re stor

Overflatespenning

γ $[\gamma] = \frac{J}{m^2}$

Surface of any liquid behaves as though it is covered by a stretched membrane

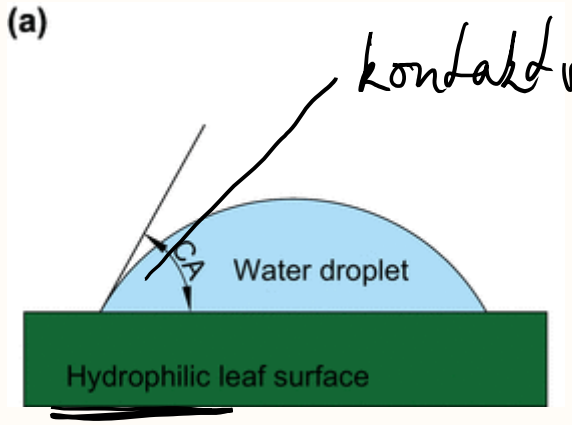
F_T

Net force on molecule at surface is into bulk of the liquid

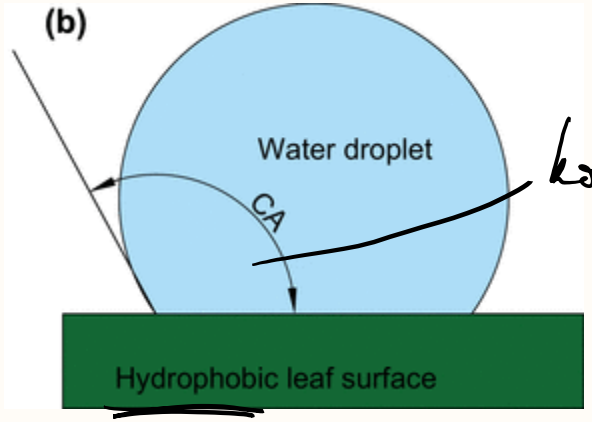
$\Sigma F = 0$

ΣF

Kontaktvinkel og fukting

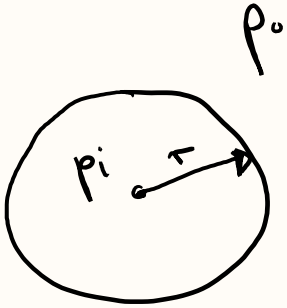


kontaktvinkel $\theta < 90°$ (hydrofil)



kontaktvinkel $> 90°$ (hydrofob)

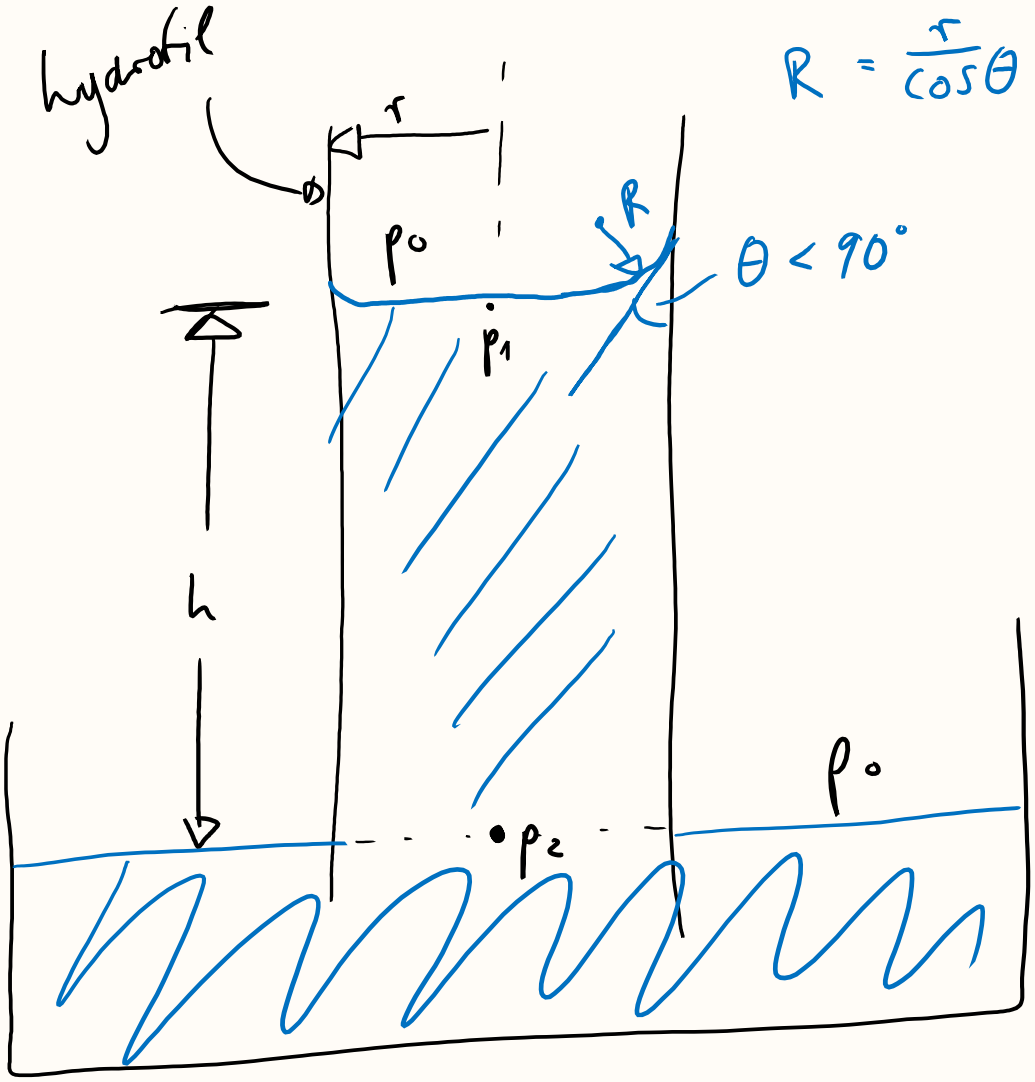
Young-Laplace likning



$p_i > p_o$

$$\Delta p = p_i - p_o = \frac{2\gamma}{r}$$

Kapillærkrefter



$$R = \frac{r}{\cos\theta}$$

$$\Delta p = p_0 - p_1 = \frac{2\gamma}{R} = \frac{2\gamma\cos\theta}{r}$$

$$p_2 = p_0 = p_1 + \rho g h$$

$$p_0 - p_1 = \rho g h$$

$$\rho g h = \frac{2\gamma\cos\theta}{r}$$

$$h = \frac{2\gamma}{r\rho g}\cos\theta$$

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