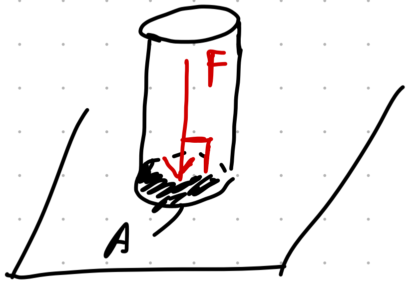
Oppsummering

- **Massetetthet:** $\rho = \dfrac{m}{V}$

  m: massen til legemet
  V: volumet til legemet

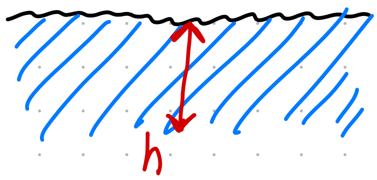
- **Trykk:** $p = \dfrac{F}{A}$

  F: kraft
  A: areal

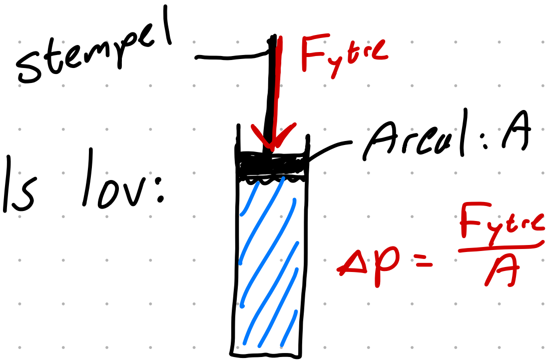


- **Hydrostatisk trykk:** $p = p_0 + \rho g h$

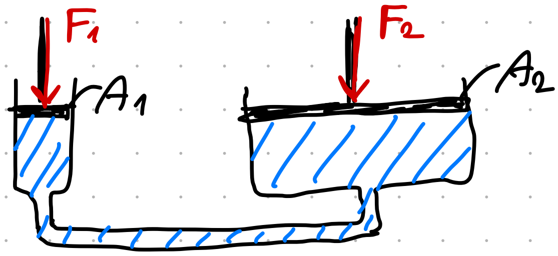
$p_0 = 101\ \text{kPa}$



- **Pascals lov:**



$\Delta p = \dfrac{F_{ytre}}{A}$

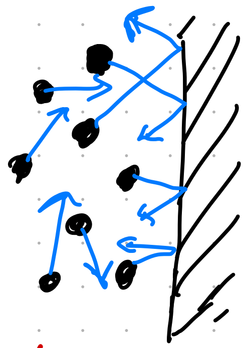


$$\boxed{\frac{F_1}{A_1} = \frac{F_2}{A_2}} \qquad \boxed{\frac{F_1}{F_2} = \frac{A_1}{A_2}}$$

- **Gasstrykk:**

  Sum av krefter fra alle molekyler som støter mot en vegg.

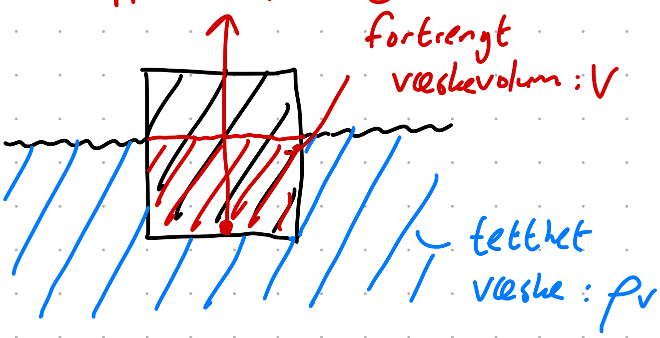
  Avhengig av:
  - Antall molekyler
  - Fart / kinetisk energi



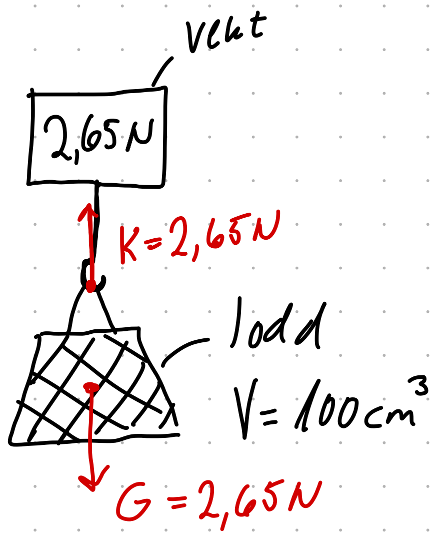
- **Oppdrift (Arkimedes lov):**

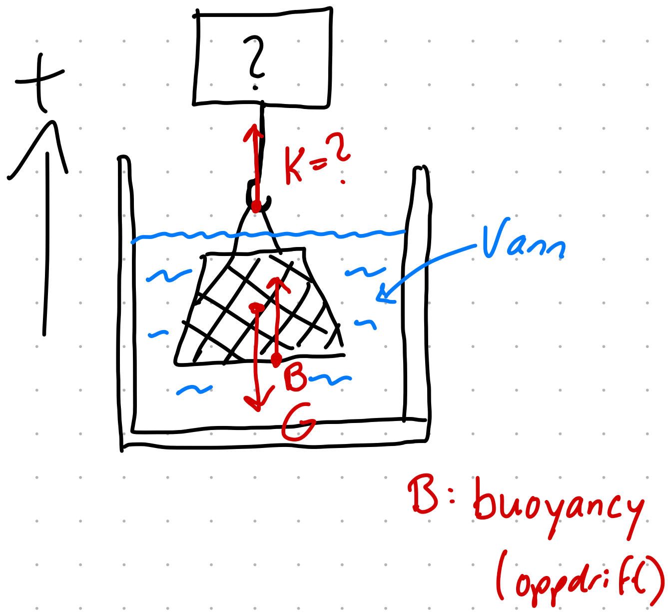
Oppdriftskraft = tyngden av den fortrengte væsken

$F_{oppdrift} = \rho_v \cdot V \cdot g$



Eksempel oppdrift





a) Hva er oppdriften?

b) Hva viser vekten når loddet er i vannet?

a) B = tyngden til fortrengt væske.

$$= m_v \cdot g$$

$$= \rho_v \cdot V \cdot g$$

$$= \underbrace{\underbrace{1000}_{10^3} \frac{kg}{m^3} \cdot \underbrace{100}_{10^2} \cdot \underbrace{(10^{-2}\,m)^3}_{10^{-6}\,m^3}}_{10^{-1}\,m^3} \cdot 9{,}81\,\frac{m}{s^2}$$

$$= 10^{-1}\,\cancel{m^3} \cdot \frac{kg}{\cancel{m^3}} \cdot 9{,}81\,\frac{m}{s^2}$$

$$\underline{B = 0{,}981\,N}$$

b) Lodd i ro $\Rightarrow \Sigma F = 0$

$$K + B - G = 0$$

$$K = G - B = 2{,}65\,N - 0{,}981\,N = \underline{1{,}67\,N}$$

6.4 TEMPERATUR

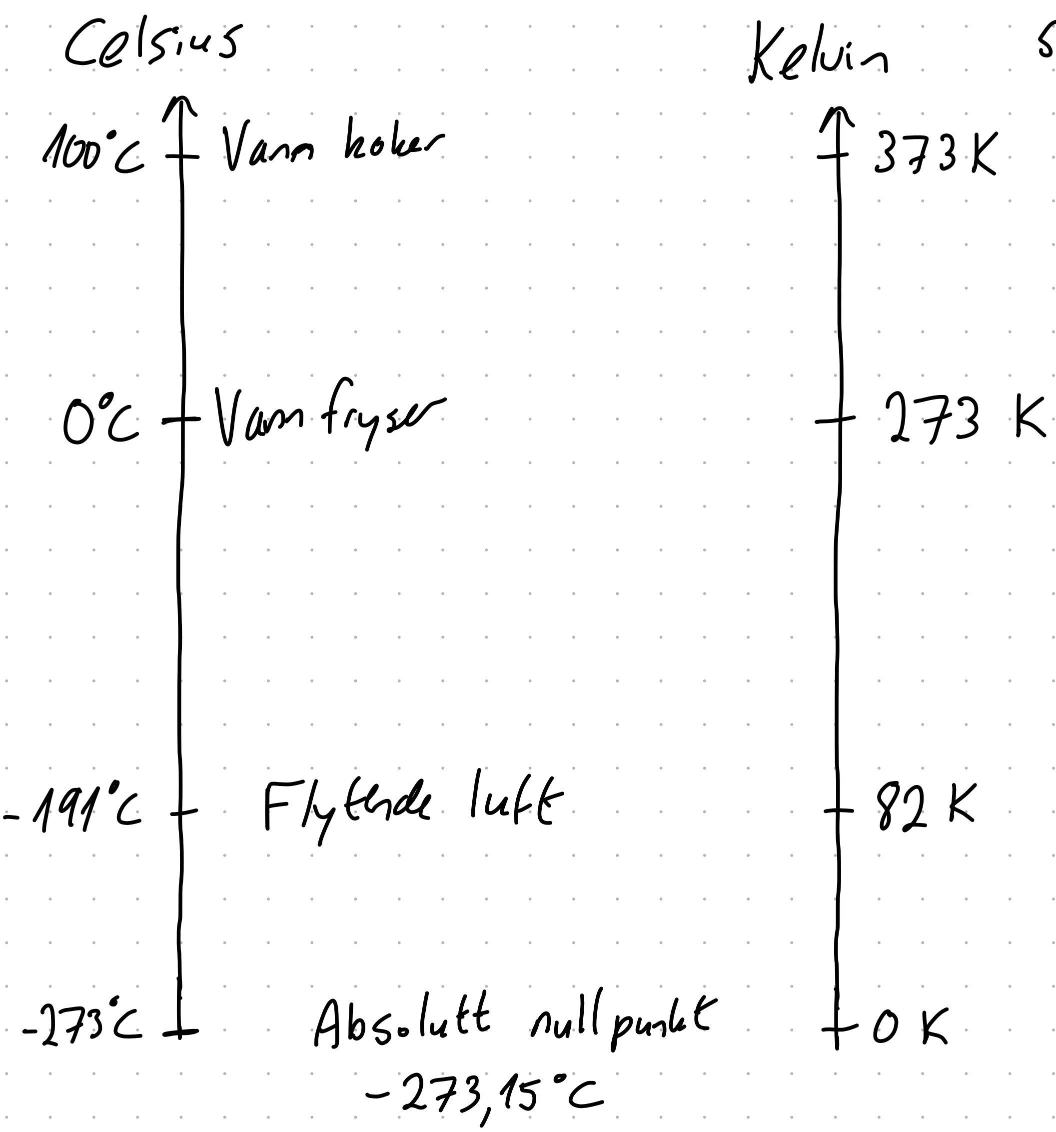
Temperatur er et mål for den gjennomsnittlige kinetiske energien til molekylene i et stoff/væske/gass

- Ikke noen grense for høyeste temperatur
- Når all bevegelse stopper, har vi nådd det absolutte nullpunkt.

Temperaturskala

Anders Celsius
svensk (1701-44)

William Kelvin
irsk (1824-1907)



Lik skala,
men forskjellig
nullpunkt

Sammenheng mellom absolutt temperatur T og celsiustemperatur t er

$$T = 273\,K + t$$

Eks. Romtemperatur $20^\circ C$.

$$T = 273\,K + 20^\circ C = 293\,K$$

Kinetisk gassteori

Antakelser / forenklinger:

- Molekylene er langt fra hverandre
- Hvert molekyl har et ubetydelig volum
- Molekylene kolliderer elastisk med hverandre og med veggene i beholderen.

Den gjennomsnittlige translatoriske kinetiske energien E_K til molekylene i en gass med absolutt temperatur T er gitt ved

$$E_K = \frac{3}{2} k T$$

k: Boltzmannkonstanten $= 1{,}38 \cdot 10^{-23} \frac{J}{K}$

Alle molekyler har samme E_K ved lik T.
Dvs. lettere molekyler har større fart enn tyngre molekyler.

Eksempel: Translatorisk energi i heliumgass (He).

a) Regn ut E_K når $T = 27°C$

$$T = 273\,K + 27°C = 300\,K$$

$$E_K = \frac{3}{2}kT = \frac{3}{2} \cdot 1{,}38 \cdot 10^{-23}\,\frac{J}{\cancel{K}} \cdot 300\,\cancel{K} = 6{,}210 \cdot 10^{-21}\,J$$

$$\underline{E_K = 6{,}2 \cdot 10^{-21}\,J}$$

b) Hva er $\Sigma_i E_K$ til alle molekylene i 4,0 g heliumgass?
Vi må finne antall molekyler.

$$m_{He} = 4{,}00\,u$$

$$1\,u = 1{,}66 \cdot 10^{-27}\,kg \quad \text{(atommasseenhet)}$$

$$m_{He} = 4{,}00 \cdot 1{,}66 \cdot 10^{-27}\,kg = 6{,}640 \cdot 10^{-27}\,kg$$

Antall molekyler i 4,0 g:

$$N = \frac{m}{m_{He}} = \frac{4{,}0 \cdot 10^{-3}\,kg}{6{,}640 \cdot 10^{-27}\,kg} = 6{,}024 \cdot 10^{23}$$

$$\Sigma_i E_K = N \cdot E_K = 6{,}024 \cdot 10^{23} \cdot 6{,}210 \cdot 10^{-21}\,J = 3{,}7 \cdot 10^{3}\,J$$

$$\underline{\Sigma_i E_K = 3{,}7\,kJ}$$

c) Hva er gjennomsnittsfarten til molekylene? $E_K = \frac{1}{2}mv^2$

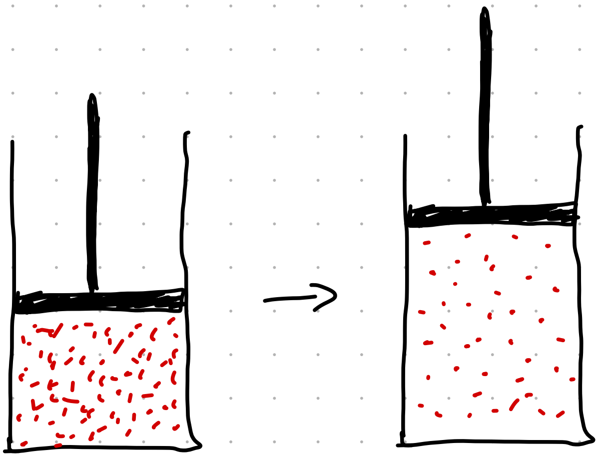
$$v = \sqrt{\frac{2E_K}{m}} = \sqrt{\frac{2 \cdot 6{,}210 \cdot 10^{-21}\,J}{6{,}640 \cdot 10^{-27}\,kg}} = \underline{\underline{1{,}4\,\frac{km}{s}}}$$

6.5 Tilstandsligningen

For en innestengt gassmengde gjelder ligningen

$$\frac{pV}{T} = \text{konstant}$$

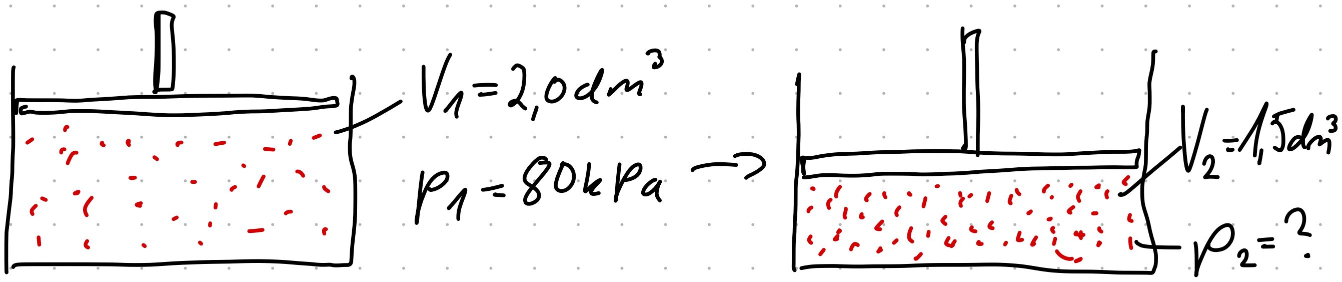
p: trykk
V: volum
T: absolutt temperatur



p_1, V_1, T_1 → p_2, V_2, T_2

$$\frac{p_1 V_1}{T_1} = \frac{p_2 V_2}{T_2}$$

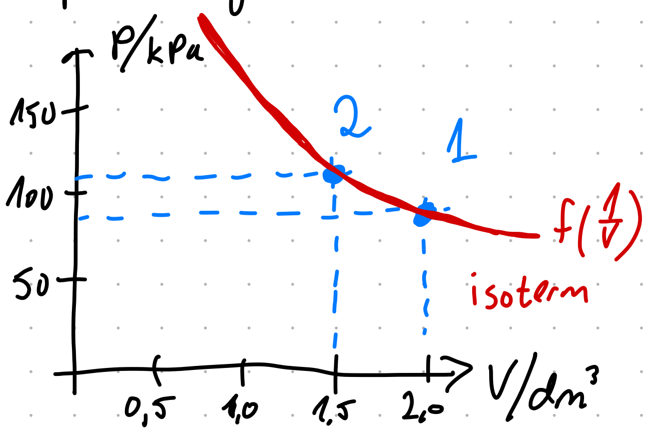
Isoterm prosess (T = konstant)



$$\frac{p_1 V_1}{\underbrace{T_1}} = \frac{p_2 V_2}{\underbrace{T_2}} \Rightarrow \frac{p_1 V_1}{V_2} = \frac{p_2 \cancel{V_2}}{\cancel{V_2}}$$

$T_1 = T_2 = T$

pV-diagram



$$p_2 = p_1 \frac{V_1}{V_2} = 80\,kPa \cdot \frac{2{,}0\,dm^3}{1{,}5\,dm^3}$$

$$p_2 = 110\,kPa = \underline{\underline{0{,}11\,MPa}}$$

$$pV = p_1 V_1$$

$$p = \frac{p_1 V_1}{V} = \frac{\text{konstant}}{V} = f\left(\frac{1}{V}\right)$$

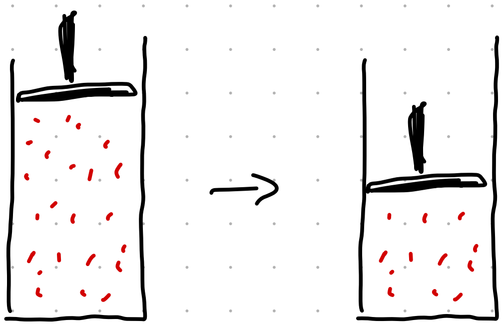
Isobar prosess ($p = \text{konstant}$)

Gass med $T_1 = 300\,K$

Reduserer volumet til det halve

under konstant trykk: $V_2 = \frac{V_1}{2}$

Hva er T_2?



V_1, T_1 $\quad$ V_2, T

$p_1 = p_2 = \text{konstant}$

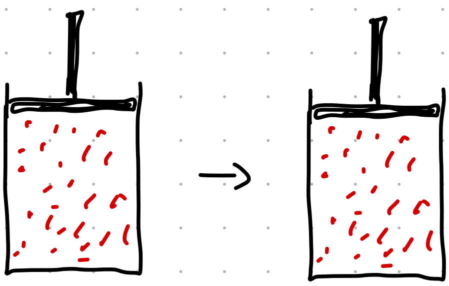
$$\frac{\overset{\nearrow p}{p_1} V_1}{T_1} = \frac{\overset{\nearrow p}{p_2} V_2}{T_2}$$

$$T_2 \cdot \frac{V_1}{T_1} = \frac{V_2}{\cancel{T_2}} \cdot \cancel{T_2}$$

$$\frac{\cancel{T_1}}{\cancel{V_1}} \cdot T_2 \frac{\cancel{V_1}}{\cancel{T_1}} = V_2 \cdot \frac{T_1}{V_1}$$

$$T_2 = T_1 \cdot \frac{V_2}{V_1} = 300\,K \cdot \underbrace{\frac{\cancel{V_1}}{2}}_{V_2} \cdot \underbrace{\frac{1}{\cancel{V_1}}}_{\frac{1}{V_1}} = \frac{300\,K}{2} = \underline{\underline{150\,K}}$$

Isokor prosess ($V = \text{konstant}$)



$T_1 = 300\,K$ $\quad$ $T_2 = ?$

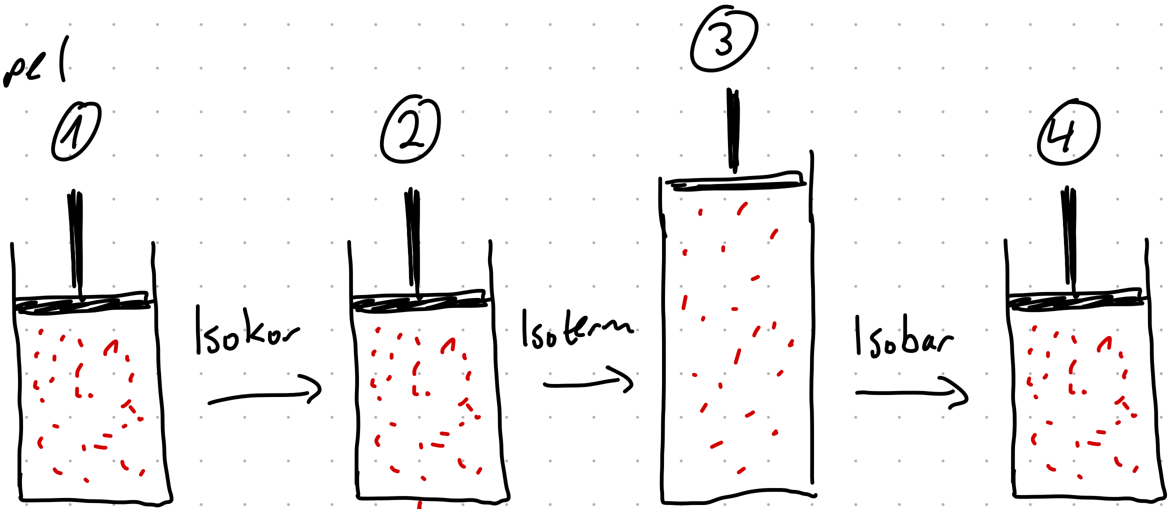
p_1 $\quad$ $p_2 = 2p_1$

$$\frac{p_1 V_1}{T_1} = \frac{p_2 V_2}{T_2} \qquad (V_1 = V_2 = V)$$

$$T_2 = T_1 \frac{p_2}{p_1} = T_1 \frac{2 p_1}{p_1} = 2 T_1$$

$$\underline{T_2 = 600\,K}$$

Eksempel



bål

1	2	3	4
$V_1 = 30\,dm^3$	$V_2 = V_1$	$V_3 = ?$	$V_4 = V_1$
$p_1 = 100\,kPa$	$p_2 = 2p_1$	$p_3 = p_1$	$p_4 = p_3$
$T_1 = 300\,K$	$T_2 = ?$	$T_3 = T_2$	$T_4 = ?$

$$\frac{p_1 V_1}{T_1} = \frac{p_2 V_2}{T_2} \rightarrow T_2 = T_1 \frac{p_2}{p_1} = T_1 \frac{2\cancel{p_1}}{\cancel{p_1}} = 2T_1 = 600\,K$$

$$\frac{p_2 V_2}{T_2} = \frac{p_3 V_3}{T_3} \rightarrow V_3 = V_2 \frac{p_2}{p_3} = V_1 \frac{2\cancel{p_1}}{\cancel{p_1}} = 2V_1 = 60\,dm^3$$

$$\frac{p_3 V_3}{T_3} = \frac{p_4 V_4}{T_4} \rightarrow T_4 = T_3 \frac{V_4}{V_3} = T_2 \frac{\cancel{V_1}}{2\cancel{V_1}} = \frac{T_2}{2} = 300\,K$$

pV – diagram for prosessene