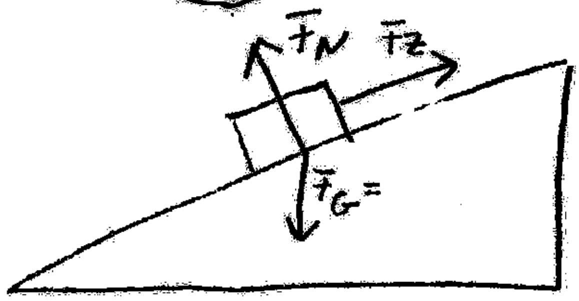
Aufgabe 1 (12)

1a) (3)



$\boxed{3}$

F_G : Gewichtskraft

F_N : von der Ebene ausgeübte Normalkraft

F_Z : vom Vater ausgeübte Zugkraft

1b) (5)

$W = \vec{F} \cdot \vec{s}$ $\boxed{1}$

$\vec{s} = \vec{v} \cdot \Delta t = 1\frac{m}{s} \cdot 600\,s = 600\,m$ $\boxed{1}$

$\vec{F} = -m \cdot g \cdot \sin\alpha \approx -20\,kg \cdot 10\,\frac{m}{s^2} \cdot 0.5 = -100\,N$ $\boxed{1}$

$W = \vec{F} \cdot \vec{s} = 6 \cdot 10^4\,J$ $\boxed{1}$ $\boxed{\text{Zahl}}$

$h = s \cdot \sin\alpha = 300\,m$ $\boxed{1}$

1c) (4)

$W_{pot} = m \cdot g \cdot h$

$W_{kin}(h=0) = W_{pot}(h=100)$

$W_{kin} = \frac{1}{2} m v^2$ $\boxed{2}$

$mgh = \frac{1}{2} m v^2$

$v = \sqrt{2gh}$ $\boxed{1}$

$= \sqrt{2 \cdot 10\,\frac{m}{s^2} \cdot 300\,m} = \sqrt{6000}\,\frac{m}{s} \approx 75\,\frac{m}{s}$ $\boxed{1}$

mit Ersatzwert

$v = \sqrt{2000}\,\frac{m}{s} \approx 45\,\frac{m}{s}$

Musterlösung

Aufgabe 2 (7)

a) (4)

$$\frac{mv^2}{r} = G\frac{mM}{r^2} \quad \boxed{2}$$

$$mv^2 = G\frac{mM}{r} \quad \text{mit } E_{kin} = \frac{1}{2}mv^2 \Rightarrow$$

$$E_{kin} = \frac{1}{2}G\frac{mM}{r} \quad \boxed{1}$$

$$E_{pot} = -G\frac{mM}{r} \quad \boxed{1}$$

b) (3)

$$\Delta E_{kin} = \frac{1}{2}GmM\left(\frac{1}{r_1} - \frac{1}{r_2}\right) \quad \boxed{1}$$

$$\Delta E_{pot} = -GmM\left(\frac{1}{r_1} - \frac{1}{r_2}\right) \quad \boxed{1}$$

$$\frac{|\Delta E_{kin}|}{|\Delta E_{pot}|} = \frac{1}{2} \quad \boxed{1}$$

(Sonderfall des Virialsatzes)

Aufgabe 3 ③

$$\Delta t' = \frac{\Delta t}{\sqrt{1-\left(\frac{v}{c}\right)^2}} \quad \boxed{2}$$

$v = 0{,}9c \;;\; \Delta t = 1h$

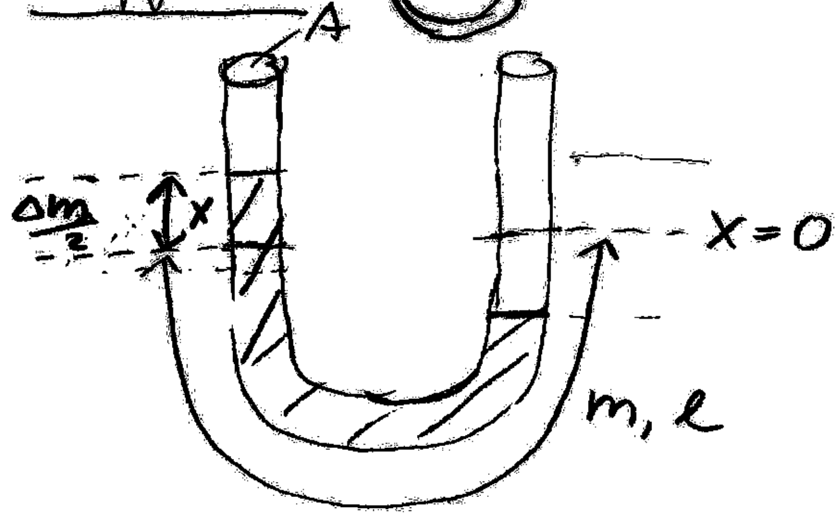
$$\Delta t' = \frac{1h}{\sqrt{1-0{,}9^2}}$$

$$\Delta t' = \frac{1h}{\sqrt{1-0{,}81}}$$

$$\Delta t' = \frac{1h}{\sqrt{0{,}19}}$$ ev. Angabe =>

$$\underline{\Delta t' = 2{,}3\,h} \quad \boxed{1}$$

Aufgabe 4 10



Rücktreibende Kraft. $F_R = \Delta m \cdot g$ $\boxed{1}$

$$\Delta m = \Delta V \cdot \rho \overset{\boxed{1}}{=} A \cdot 2x \cdot \rho \quad \boxed{2}$$

$$\Rightarrow F_R = A \cdot 2x \cdot \rho \cdot g$$

Bewegungsgleichung: $m\ddot{x} = -A\,2x\,\rho \cdot g$

$\Rightarrow$ Beschleunigung ~ Auslenkung und dieser entgegengerichtet

$\Rightarrow$ Schwingung harmonisch

(oder $F_R \sim x \Rightarrow$ ") $\boxed{1}$

$$\omega^2 = \frac{\text{rücktreibende Kraft}}{\text{Einheitsmasse} \cdot \text{Einheitsauslenkung}}$$

$$\rightarrow \omega^2 = \frac{A \cdot 2x \cdot \rho \cdot g}{m \cdot x} \;\boxed{1}\;; \quad m = A \cdot \ell \cdot \rho \;\boxed{1}$$

$$\rightarrow \omega^2 = \frac{2g}{\ell}\;; \quad \omega = \sqrt{\frac{2g}{\ell}} \;\boxed{1}$$

$$T = \frac{2\pi}{\omega} = 2\pi\sqrt{\frac{\ell}{2g}} \;\boxed{1} \qquad \ell = \frac{10^4\,\text{mm}^3}{50\,\text{mm}^2} = 200\,\text{mm} = 0.2\,\text{m} \;\boxed{1}$$

$$= 2\pi\sqrt{\frac{0.2\,\text{m}}{2 \cdot 10\,\text{m}}\,\text{s}^2} = 0{,}63\,\text{s} \quad (0.6\,\text{s auch o.k.})$$

Aufgabe 5 (5)

a) $p = \hbar k$ $\quad$ (oder $p = \frac{h}{\lambda}$)

(2)

$$mv = \frac{h}{2\pi} \cdot \frac{2\pi}{\lambda}$$

$$v = \frac{h}{m\lambda} \quad \boxed{1}$$

$$v = \frac{6{,}6 \times 10^{-34}\ Js}{1{,}7 \times 10^{-27}\,kg \cdot 0{,}3 \times 10^{-9}\,m}$$

$$v \approx \frac{66}{1{,}7 \cdot 3} \times 10^{2} \ \frac{kg\,\frac{m^2}{s^2}\,s}{kg\,m}$$

$$v \approx \frac{22}{1{,}7} \times 10^{2}\ \frac{m}{s}$$

$$v \approx 1300\,\frac{m}{s} \quad \boxed{1}$$

b) $\bar{v} = \sqrt{\frac{8kT}{\pi m}}$ $\boxed{1}$ $\Longrightarrow$ $T = \frac{v^2 \pi m}{8k}$ $\boxed{1}$

(3)

$$T \approx \frac{1300^2\,\frac{m^2}{s^2} \cdot 3 \cdot 1{,}7 \times 10^{-27}\,kg}{8 \cdot 1{,}4 \times 10^{-23}\,J/K}$$

$$T \approx 77\,K \quad \boxed{1}$$

Aufgabe 6 (17)

a) $pV = nRT$

(3) $\Rightarrow T = \frac{pV}{nR}$ $\boxed{1}$

$$T_1 = \frac{10^5 \cancel{Pa} \cdot 16.8 \cdot 10^{-3} m^3 K}{m^2\, 8.4\, J} = 200\,K \quad \boxed{1}$$

$T_2 = 400\,K$ (da $V_2 = 2V_1$) $\boxed{1}$

b) Weg 1–2: isobar

(14) ${}_1W_2 = -p(V_2 - V_1) = -10^5\,Pa \cdot 16.8 \cdot 10^{-3}\,m^3 = -1.68 \cdot 10^3\,J$ $\boxed{1}$ $\boxed{1/2}$

${}_1Q_2 = n c_p (T_2 - T_1)$ $\boxed{1}$

$c_p = R + c_v$; $c_v = \frac{3}{2} R$ (1 atomiges ideales Gas, 3 Freiheitsgrade der Transl.)

$c_p = \frac{5}{2} R$ $\boxed{1}$

$${}_1Q_2 = \frac{5}{2} \cdot 8.4 \frac{J}{K\,mol} \cdot 1\,mol \cdot 200\,K$$

$= 4.2 \cdot 10^3\,J$ $\boxed{1/2}$

$\Delta U = {}_1W_2 + {}_1Q_2 = -1.68 \cdot 10^3\,J + 4.2 \cdot 10^3\,J = 2.52 \cdot 10^3\,J$ $\boxed{1/2}$

$\boxed{1}$ (alternativ: $\Delta U = n c_v \Delta T = 2.52 \cdot 10^3\,J$)

For "first Law" only 1 point
i.e. below no more points for 1st law

Weg 2-3 : isochor

$${}_2W_3 = 0 \quad \boxed{1/2}$$

$${}_2Q_3 = n\,c_v(T_3 - T_2) \overset{\boxed{1}}{=} -\frac{3}{2}R \cdot 200\,K \cdot mol$$

$$= -2{,}52 \cdot 10^3\,J \quad \boxed{1/2}$$

$$\Delta U = {}_2W_3 + {}_2Q_3 = -2{,}52 \cdot 10^3\,J \quad \boxed{1/2}$$

Weg 3-1 : isotherm

$${}_3W_1 = \left(-\int_{V_2}^{V_1} p\,dV = -nRT\int_{V_2}^{V_1}\frac{dV}{V} = -nRT\ln\frac{V_1}{V_2}\right)$$

$$= nRT\ln\frac{V_2}{V_1} \quad \boxed{1}$$

$$= 8{,}4 \cdot 200 \cdot 0{,}7\,J = 1200\,J \quad \boxed{1/2}$$

$$\Delta U = (n\,c_v\,\Delta T) = 0 \quad \boxed{1}$$

$${}_3Q_1 = \Delta U - {}_3W_1 = -1200\,J \quad \boxed{1/2}$$

Kreisprozeß

$$\oint dU = 2.52 \cdot 10^3\,J - 2.52 \cdot 10^3\,J = 0 \quad \boxed{1}$$

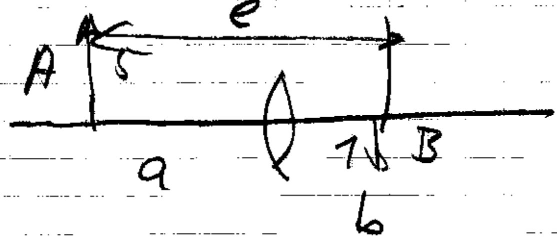
$${}_1W_2 + {}_2W_3 + {}_3W_1 = -1.68 \cdot 10^3\,J + 1.2 \cdot 10^3\,J$$

$$= -0.48 \cdot 10^3\,J \quad \boxed{1}$$

$${}_1Q_2 + {}_2Q_3 + {}_3Q_1 = 4.2 \cdot 10^3\,J - 2.52 \cdot 10^3\,J - 1{,}2\,10^3\,J$$

$$= +0.48 \cdot 10^3\,J \quad \boxed{1}$$

Aufgabe 7 (6)



$$\frac{1}{f} = \frac{1}{a} + \frac{1}{b} \quad \boxed{1}$$

$$\frac{a}{b} = \frac{A}{B} =: k = 5 \quad \boxed{1} \qquad a + b = \ell \quad \boxed{1}$$

$$a = kb \qquad (k+1)b = \ell \Rightarrow b = \frac{1\,\text{m}}{6}$$

also $b \approx 0{,}17\,\text{m}$; $a \approx 0{,}83\,\text{m}$ $\boxed{1}$

$$\left(\frac{1}{f} = \frac{1}{a} + \frac{1}{b} = \frac{1}{0{,}17\,\text{m}} + \frac{1}{0{,}83\,\text{m}} \Rightarrow f \approx 0{,}14\,\text{m}^{*} \right)$$

oder:

$$\frac{1}{f} = \frac{k+1}{k\ell} + \frac{k+1}{\ell} ; \quad \frac{1}{f} = \frac{k+1+k(k+1)}{k\ell}$$

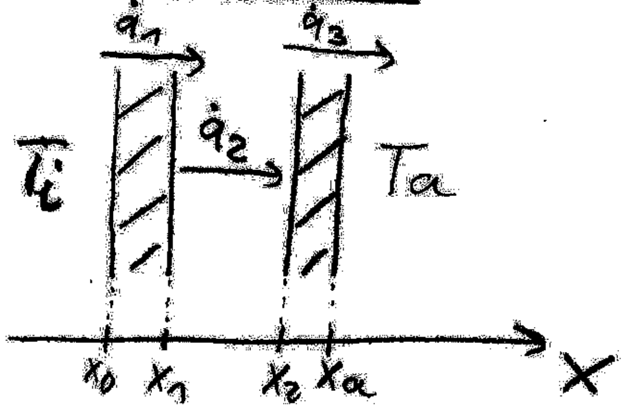
$$\frac{1}{f} = \frac{1+2k+k^2}{k\ell} ; \quad \frac{1}{f} = \frac{(1+k)^2}{k\ell}$$

$$f = \frac{k\ell}{(1+k)^2}$$

$$f = \frac{5 \cdot 1\,\text{m}}{36} \quad \boxed{1}$$

$$f \approx 0{,}14\,\text{m} \quad \boxed{1} \ {}^{*}$$

Aufgabe 8 ④



$T_1 = T(x_1)$
$T_2 = T(x_2)$

Annahme: $T_a < T_i$;
für T_i T_a Wärmefluss in entgegengesetzter Richtung.

$\boxed{1}$ $\dfrac{dq}{dt} = \lambda \dfrac{dT}{dx}$ $\left(\text{oder } \dfrac{dQ}{dt} = \lambda A \dfrac{dT}{dx} \right)$

mit A: Fensterfläche

<u>Weg 1</u>:

$\boxed{1}$ $\dot{q}_1 = \lambda_1 \dfrac{(T_i - T_1)}{h_1}$

$\boxed{1/2}$ $\dot{q}_2 = \lambda_2 \dfrac{(T_1 - T_2)}{h_2}$

$\boxed{1/2}$ $\dot{q}_3 = \lambda_1 \dfrac{(T_2 - T_a)}{h_1}$

unter stat. Bedingungen gilt: $\dot{q}_1 = \dot{q}_2 = \dot{q}_3$ $\boxed{1}$

Weg 2:

$\boxed{1}$ $\dot{Q} = \dfrac{T_i - T_a}{R_G}$

$\boxed{1}$ $R_G = 2R_1 + R_2$

$\boxed{1/2}$ $R_1 = \dfrac{h_1}{\lambda_1}$

$\boxed{1/2}$ $R_2 = \dfrac{h_2}{\lambda_2}$