4 Airplane speed is $900 \frac{km}{h}$.

$$\therefore \quad 0.1s \cdot \frac{1h}{3600s} \cdot 900 \frac{km}{h} = 0.025\,km$$
$$= 25\,m$$

Conservation Laws

Total momentum:

$$\vec{p}_{tot} = \vec{p}_1 + \vec{p}_2 + \dots \vec{p}_n = const.$$

Total energy:

$$E_{tot} = E_{kin} + E_{pot} + E_{chem} + \dots = const.$$

Total Angular momentum:

$$\vec{L}_{tot} = \vec{L}_1 + \vec{L}_2 + \dots \vec{L}_n = const.$$

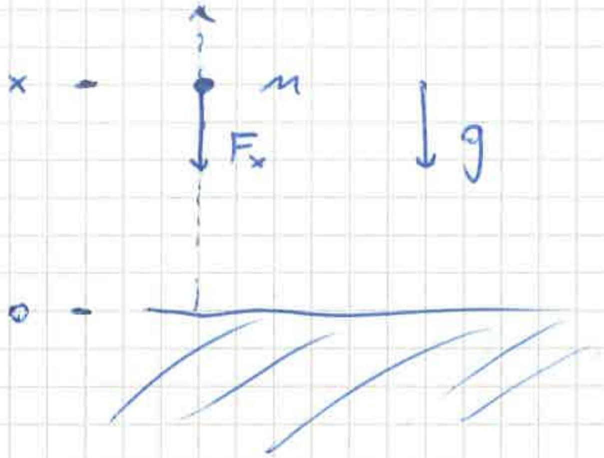
Total mass:

$$m_{tot} = m_1 + m_2 + \dots m_n = const.$$

Conservation of Energy

In a closed system, the sum of all energies is constant.

$$E_{tot} = E_{kin} + E_{pot} + \cdots = const.$$



$$E_{pot} = mgx$$

$$F_x = -mg$$

Konstant

$$E_{pot} = -F_x x \qquad F_x = ma = m\frac{dv}{dt}$$

$$\cancel{E_{pot} = -m\frac{dv}{dt}}$$

$$\frac{dE_{pot}}{dt} = -F_x \frac{dx}{dt} = -F_x v$$

$$\frac{dE_{pot}}{dt} = -m\frac{dv}{dt}v \qquad \frac{d}{dt}(v^2) = 2v\frac{dv}{dt}$$

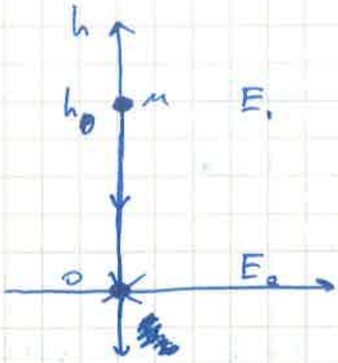
$$\frac{dv}{dt}v = \frac{1}{2}\frac{d}{dt}(v^2)$$

$$\frac{dE_{pot}}{dt} = -m\frac{1}{2}\frac{d}{dt}(v^2) = -\frac{d}{dt}\underbrace{\left(\frac{1}{2}mv^2\right)}_{E_{kin}}$$

$$\frac{dE_{pot}}{dt} = -\frac{dE_{kin}}{dt}$$

$$\frac{d}{dt}\left(E_{pot} + E_{kin}\right) = 0$$

$$\boxed{E_{pot} + E_{kin} = \text{Konstant}}$$



$\downarrow \vec{g}$

$$E_1 = E_2$$

$$E_{kin\,1} + E_{pot\,1} = E_{kin\,2} + E_{pot\,2}$$

$$\frac{1}{2} m v_1^2 + m g h_1 = \frac{1}{2} m v_2^2 + m g h_2$$

(1) $v_1 = 0$, $h_1 = h_0$ (2) $v_2 = v_E$, $h_2 = 0$

$\therefore$

$$0 + m g h_0 = \frac{1}{2} m v_E^2 + 0$$

$$v_E = \sqrt{2 g h_0}$$

$g = 9.8\ m/s^2$

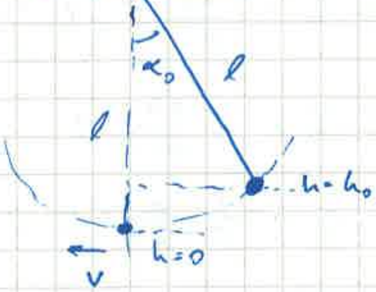
$h_0 = 10\ m$

$\therefore\ v_E = \sqrt{196\ m^2/s^2}$

$v_E = 14\ m/s$

$$v_E = 14\ \frac{m}{s} \cdot \frac{1\ km}{1000\ m} \cdot \frac{3600\ s}{1\ hr}$$

$v_E = 50\ km/hr$



$$E_1 = E_2$$

$$E_{kin\,1} + E_{pot\,1} = E_{kin\,2} + E_{pot\,2}$$

$$\frac{1}{2} m v_1^2 + m g h_1 = \frac{1}{2} m v_2^2 + m g h_2$$

(1) $v_1 = 0$, $h_1 = h_0$ (2) $v_2 = v$, $h_2 = 0$

$$0 + m g h_0 = \frac{1}{2} m v^2 + 0$$

$$v^2 = 2 g h_0$$

$h_0 = l - l \cos \alpha_0$

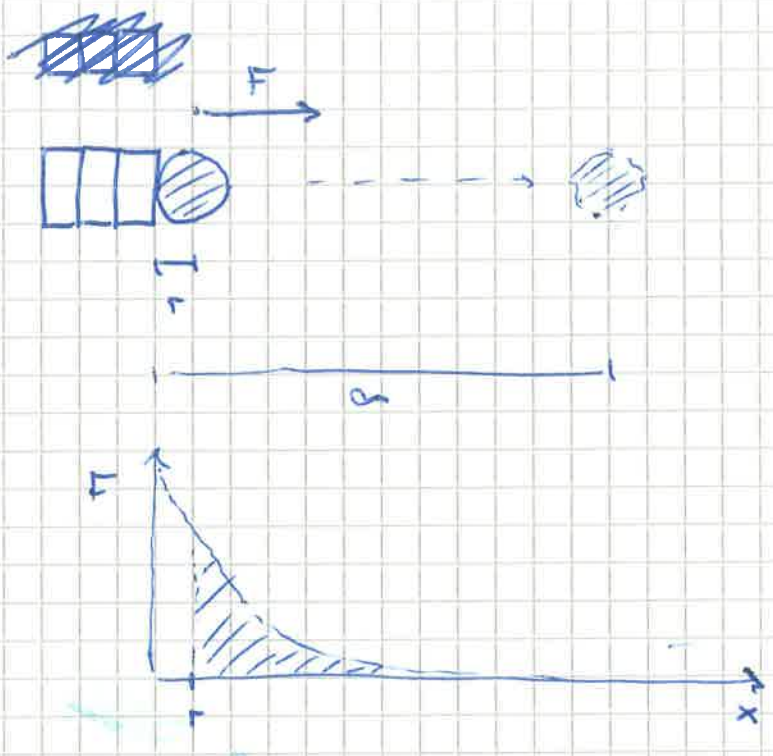
$h_0 = l(1 - \cos \alpha_0)$

$$v = \sqrt{2 g h_0}$$

$$v = \sqrt{2 g l (1 - \cos \alpha_0)}$$

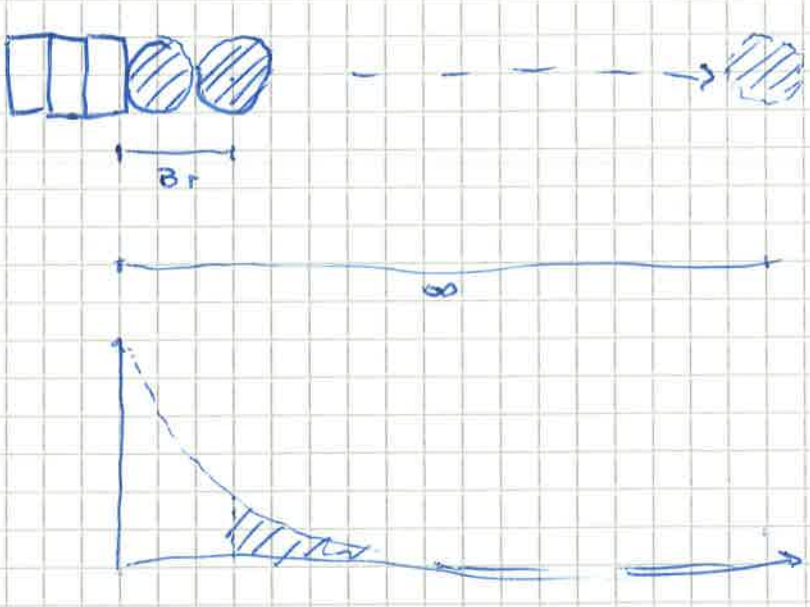
$\boxed{Exp}$

Gauss Kanone



$$dW = F \cdot dx = dE_{pot_1}$$

$$E_{pot_1} = \int_r^\infty F\,dx$$



$$E_{pot_2} = \int_{3r}^\infty F\,dx$$

$$E_{kin_1} = 0$$
$$E_{pot_1} = \int_r^\infty F\,dx$$

$$E_{kin_2} = \frac{1}{2} m v^2$$
$$E_{pot_2} = \int_{3r}^\infty F\,dx$$

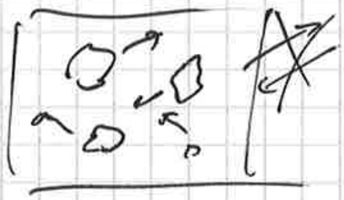
$$E_{kin_1} + E_{pot_1} = E_{kin_2} + E_{pot_2}$$

$$\int_r^\infty F\,dx = \frac{1}{2} m v^2 + \int_{3r}^\infty F\,dx$$

$$\frac{1}{2} m v^2 = \int_r^\infty F\,dx - \int_{3r}^\infty F\,dx = \int_r^{3r} F\,dx$$

$$\boxed{v = \sqrt{\frac{2}{m} \int_r^{3r} F\,dx}}$$

Impuls übertragung
auf die Magneten
die Kugeln



$\Delta p \longrightarrow$ no ext forces

$$\vec{P}_{tot} = \sum_i \vec{p}_i = \sum_i m_i \vec{v}_i$$

$$\frac{d\vec{P}_{tot}}{dt} = \sum_i m_i \frac{d\vec{v}_i}{dt} = \sum_i m_i a_i = \sum_i F_i$$

$$\frac{dP_{tot}}{dt} = F_{tot}$$

IF $F_{tot} = 0$,

then $\frac{dP_{tot}}{dt} = 0$

$$P_{tot} = \text{const.}$$

Conservation of Momentum

$$\vec{p}_{tot} = \vec{p}_1 + \vec{p}_2 + \dots + \vec{p}_n = \text{const.}$$

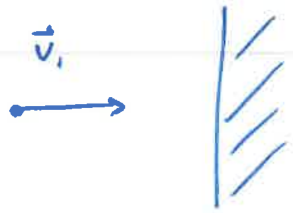
$\boxed{\text{Expl}}$: carts & spring

Examples

Elastic reflection of particle against wall:

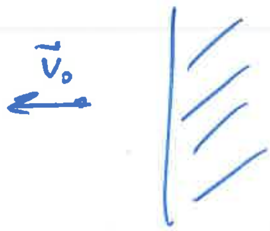
(1)

$\vec{v}_1$



(2)

$\vec{v}_2$



$\vec{v}_1 \parallel \vec{v}_2$

$\vec{v}_1$, $\vec{v}_2$ are opposite

Conservation of Energy:

$$E_1 = E_2$$

$$E_{kin\,1} = E_{kin\,2}$$

$$\frac{1}{2} m v_1^2 = \frac{1}{2} m v_2^2$$

$$v_1^2 = v_2^2$$

$$V_1 = V_2$$

Conservation of Momentum:

$$\vec{p}_1 = \vec{p}_2$$

$$m\vec{v}_1 + \vec{p}_{wall_1} = m\vec{v}_2 + \vec{p}_{wall_2}$$

$$m v_1 + p_{wall_1} = -m v_1 + p_{wall_2}$$

$$2 m v_1 = p_{wall_2} - p_{wall_1} = \Delta p_{wall}$$