

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

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

## Conservation Laws

Total momentum:

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

Total energy:

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

Total Angular momentum:

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

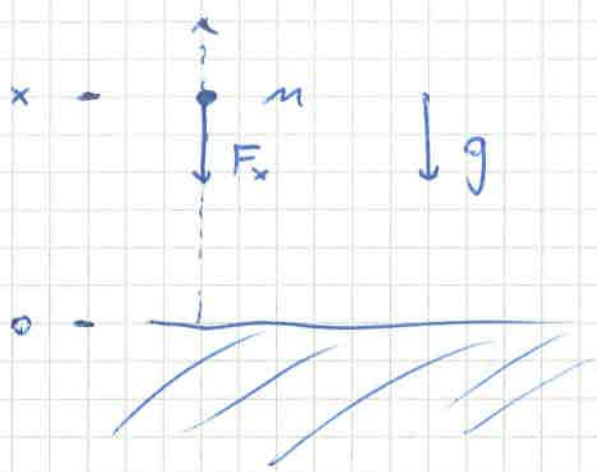
Total mass:

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

## Conservation of Energy

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

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



$$E_{\text{pot}} = m g x$$

$$F_x = - m g$$

↘ Konstant

$$E_{\text{pot}} = - F_x x$$

$$F_x = m a = m \frac{dv}{dt}$$

~~$$E_{\text{pot}} = - m g x$$~~

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

$$\frac{dE_{\text{pot}}}{dt} = - m \frac{dv}{dt} v$$

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

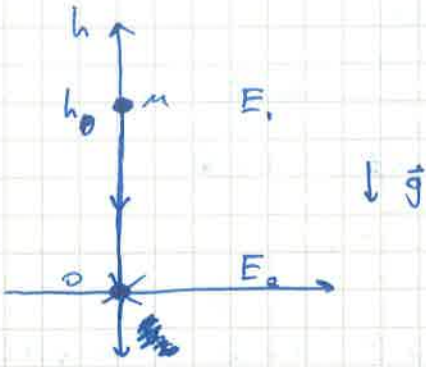
~~$$\frac{dv}{dt} v = \frac{1}{2} \frac{d}{dt}(v^2)$$~~

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

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

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

$$\left. E_{\text{pot}} + E_{\text{kin}} = \text{Konstant} \right\}$$



$$E_1 = E_2$$

$$E_{kin1} + E_{pot1} = E_{kin2} + E_{pot2}$$

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

$$\textcircled{1} \quad \begin{aligned} v_1 &= 0 \\ h_1 &= h_0 \end{aligned}$$

$$\textcircled{2} \quad \begin{aligned} v_2 &= v_E \\ h_2 &= 0 \end{aligned}$$

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

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

$$g = 9.8 \frac{m}{s^2}$$

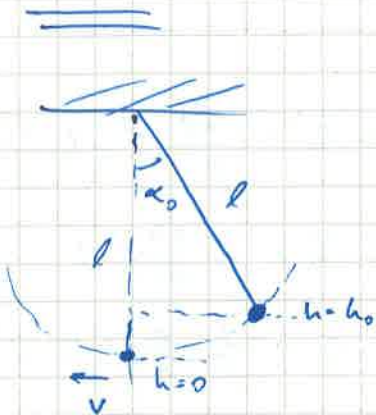
$$h_0 = 10 \text{ m}$$

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

$$v_E = 14 \frac{m}{s}$$

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

$$v_E = 50 \frac{\text{km}}{\text{hr}}$$



$$E_1 = E_2$$

$$E_{kin1} + E_{pot1} = E_{kin2} + E_{pot2}$$

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

$$\textcircled{1} \quad \begin{aligned} v_1 &= 0 \\ h_1 &= h_0 \end{aligned}$$

$$\textcircled{2} \quad \begin{aligned} v_2 &= v \\ h_2 &= 0 \end{aligned}$$

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

$$v^2 = 2 g h_0$$

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

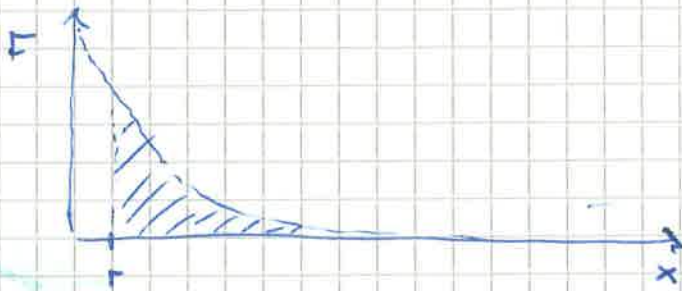
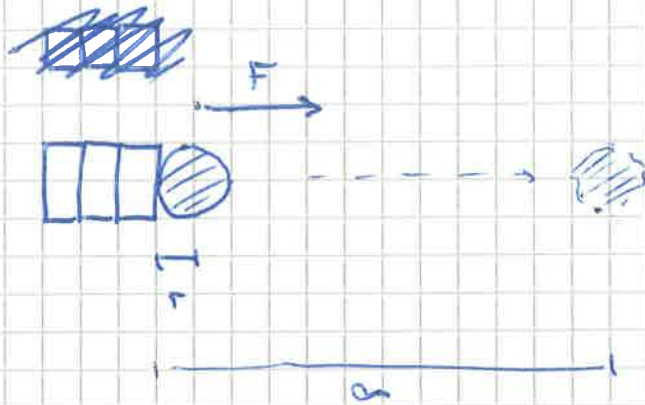
$$v = \sqrt{2 g l (1 - \cos \alpha_0)}$$

$$h_0 = l - l \cos \alpha_0$$

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

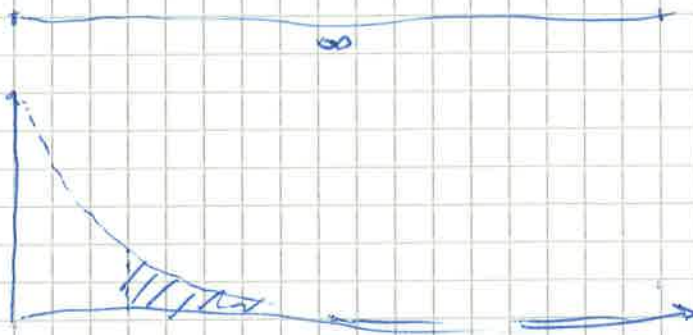
Exp

# Gauss Kanone



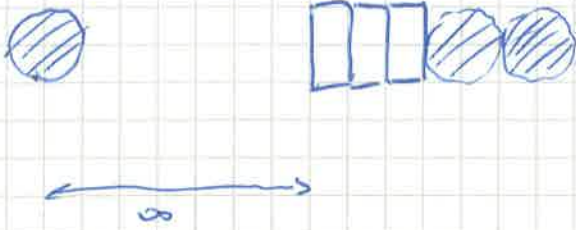
$$dW = F \cdot dx = dE_{\text{pot}_1}$$

$$E_{\text{pot}_1} = \int_r^{\infty} F dx$$



$$E_{\text{pot}_2} = \int_{3r}^{\infty} F dx$$

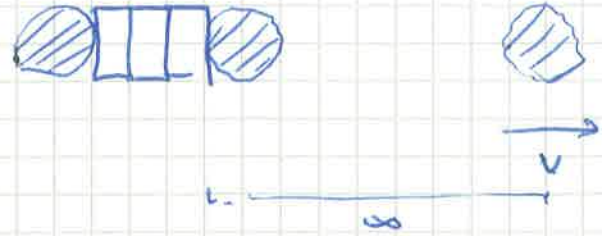
①



$$E_{kin,1} = 0$$

$$E_{pot,1} = \int_r^{\infty} F dx$$

②



$$E_{kin,2} = \frac{1}{2} m v^2$$

$$E_{pot,2} = \int_{3r}^{\infty} F dx$$

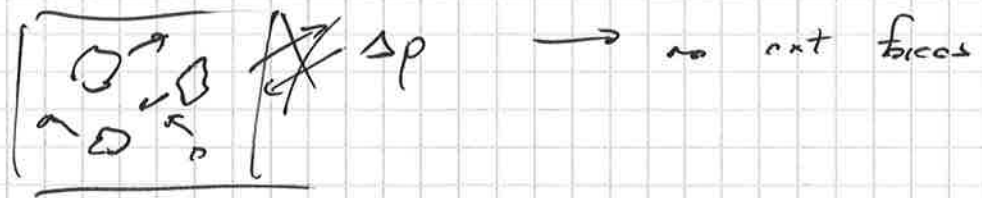
$$E_{kin,1} + E_{pot,1} = E_{kin,2} + E_{pot,2}$$

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

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

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

Impulsübertragung  
auf die Magneten  
die Kerne



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

$$\frac{d\vec{P}_{\text{tot}}}{dt} = \sum_i m_i \frac{d\vec{v}_i}{dt} = \sum_i m_i \vec{a}_i = \sum_i \vec{F}_i$$

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

IF  $F_{\text{tot}} = 0$ ,

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

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

# Conservation of Momentum

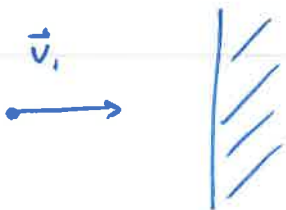
$$\vec{p}_{\text{tot}} = \vec{p}_1 + \vec{p}_2 + \dots + \vec{p}_n = \text{const.}$$

Exp: carts & spring

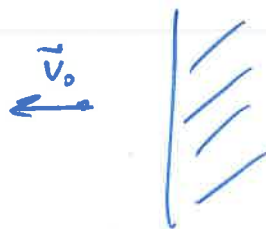
## Examples

Elastic reflection of particle against wall:

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②



$\vec{v}_1 \parallel \vec{v}_2$   
 $\vec{v}_1, \vec{v}_2$  are  
 opposite ~~to~~

Conservation of  
Energy:

$$E_1 = E_2$$

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

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

$$v_1^2 = v_2^2$$

$$v_1 = v_2$$

Conservation of Momentum:

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

$$m\vec{v}_1 + \vec{p}_{\text{wall}1} = m\vec{v}_2 + \vec{p}_{\text{wall}2}$$

$$m v_1 + p_{\text{wall}1} = -m v_1 + p_{\text{wall}2}$$

$$2 m v_1 = p_{\text{wall}2} - p_{\text{wall}1} = \Delta p_{\text{wall}}$$