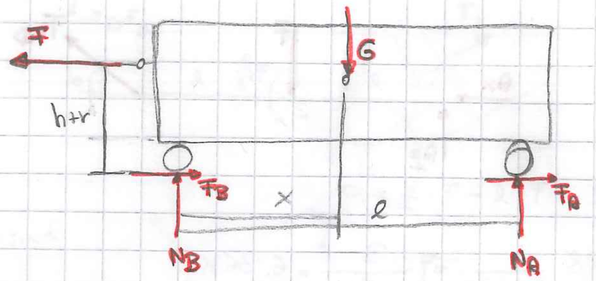
24:



Normalkräfte:

$\circlearrowleft: \sum_i M_{B_i} = 0: \quad N_A \cdot l - G \cdot x + F \cdot (h+r) = 0$

$\rightarrow \underline{N_A} = \left(G \cdot x - F \cdot (h+r)\right)\frac{1}{l} = \left(m \cdot g \cdot x - F \cdot (h+r)\right)\frac{1}{l} = \underline{16.5\,kN}$

$+\uparrow: \sum_i F_{y_i} = 0: \quad N_B + N_A - G = 0$

$\rightarrow \underline{N_B} = G - N_A = \underline{42.3\,kN}$

N_A & N_B sind unabhängig davon, ob die Räder blockiert sind oder nicht.

A & B blockiert:

$F_{A_{max}} = \mu_h N_A = \underline{6.6\,kN}$

$F_{B_{max}} = \mu_h N_B = \underline{16.92\,kN}$

$F_{A_{max}} + F_{B_{max}} = 23.52\,kN > F = 10\,kN$

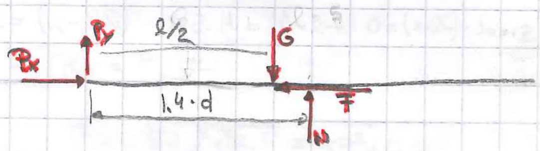
$\rightarrow$ Grubenwagen steht still.

Wenn nur A blockiert, dann gilt: $F_{A_{max}} = 6.6\,kN < 10\,kN = F$

$\rightarrow$ Wagen rollt.

Bsp. 25:

Brett:



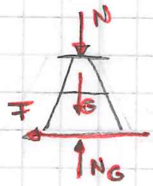
$G = l \cdot q = 5.4\,m \cdot 50\,N\,m^{-1} = \underline{270\,N}$

$\sum_i M_{P_i} = 0: \quad -G \cdot \frac{l}{2} + N \cdot 1.4d = 0$

$\underline{N} = G \cdot \frac{l}{2} \frac{1}{1.4d} = 270\,N \cdot \frac{5.4\,m}{8.4\,m} = \underline{173.57\,N}$

Gleiten des Bretts am Sägebock:

$\underline{P_x} = F_{max} = \mu \cdot N = 0.5 \cdot 173.57\,N = \underline{86.79\,N}$



Gleiten des Bockes am Boden:

$\sum_i F_{y_i} = 0: \quad N_G - G - N = 0$

$\underline{N_G} = G + N = 75\,N + 173.57\,N = \underline{248.57\,N}$

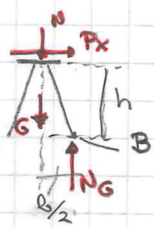
$\underline{P_x^{(g)}} = F'_{max} = \mu' \cdot N_G = 0.3 \cdot 248.57\,N = \underline{74.57\,N} < P_x$ ... mind. Gleiten

Kippen des Bockes:

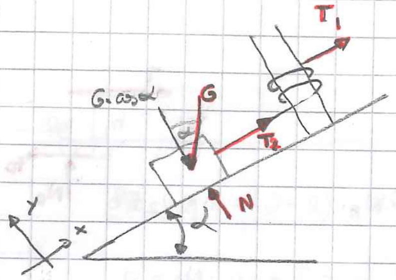
$\sum_i M_{B_i} = 0: \quad N \cdot \frac{b}{2} - P_x \cdot h + G \cdot \frac{b}{2} = 0$

$P_x = (N+G)\frac{b}{2h} = (173.57\,N + 75\,N)\frac{0.6\,m}{2 \cdot 0.9\,m}$

$\underline{P_x^{(k)} = 82.86\,N > P_x^{(g)}} \rightarrow$ Bock gleitet!



Bsp. 26:



NB: Euler-Eytelwein-Glg.

$F_Z \leq F_H \cdot e^{\mu_H \cdot \alpha}$ haften

$\mu_H \to \mu_G$ gleiten

F_Z ... ziehende Kraft (Auto-Ende)

F_H ... haltende Kraft (Mann)

$\sum F_x = 0: \quad -G \cdot \sin\alpha + T_2 = 0$

$\rightarrow \underline{T_2 = G \cdot \sin\alpha = m \cdot g \cdot \sin\alpha}$

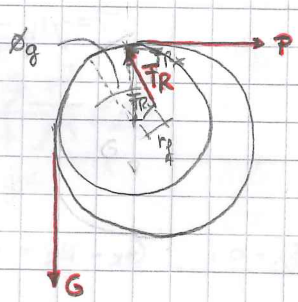
$\underline{T_2 = 11\,407.7 N}$

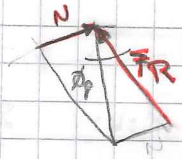
Seilreibung: $T_2 \leq T_1 e^{\mu_g \beta}$ $\qquad T_1 = F_A$

$e^{\mu_g \beta} \geq \frac{T_2}{F_A}$

$\beta \geq \ln\left(\frac{T_2}{F_A}\right) \frac{1}{\mu_g} = 12.13 \text{ rad} \rightarrow \underline{\beta} \geq \frac{\beta \cdot 180°}{\pi} = \underline{695°} \quad , \quad \underline{n} \geq \frac{695°}{360°} = \underline{1.93}$

Bsp. 27:





Gleitreibungswinkel: $\varnothing_g = \frac{R}{N} = \frac{\mu_g \cancel{N}}{\cancel{N}} = \mu_g$

R_F bei Drehung verschoben, sodass

$r \sin\varnothing_g = r_f$

$\varnothing_g = \tan^{-1}\mu_g$ aus $\mu_g = \frac{F_R}{N} = \tan\varnothing_g$

also: $\underline{\varnothing_g} = \tan^{-1} 0.3 = \underline{16.7°} \rightarrow r_f = r \cdot \sin\varnothing_g = \underline{14.37 mm}$

Glgw.:

$\sum_i F_{y_i} = 0: \quad F_{Ry} - G = 0 \rightarrow \underline{F_{Ry} = G = 20 N}$

$\sum_i F_{x_i} = 0: \quad P - F_{Rx} = 0 \rightarrow F_{Rx} = P$

also ist die resultierende: $F_R = \sqrt{F_{Rx}^2 + F_{Ry}^2} = \sqrt{P^2 + (20N)^2}$

Moment um Ursprung:

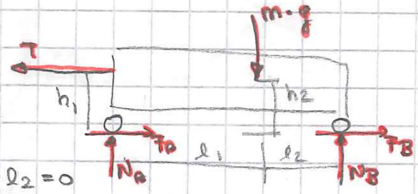
$\sum_i M_{O_i} = 0: \quad F_R \cdot r_f + G \cdot R + P \cdot R = 0$

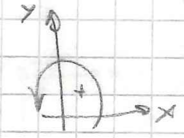
$\sqrt{P^2 + (20N)^2}\ 14.367 mm + 20N \cdot 56.25 mm + P \cdot 56.25 mm = 0$

Lsg. $\rightarrow \underline{P = 29 N}$

Bsp. 28:

(a) Hinterradantrieb:





$F_B = 0$ $\qquad \sum_i M_{B_i} = 0: \quad T \cdot h_1 - N_A \cdot (l_1 + l_2) + m \cdot g \cdot l_2 = 0$

$\sum_i F_{x_i} = 0: \quad -T + F_A = -T + \mu_h \cdot N_A = 0$

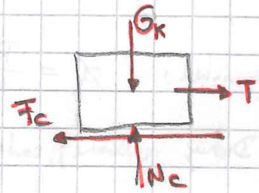
aus (M) $\rightarrow \quad N_A = \frac{1}{l_1 + l_2}(T \cdot h_1 + m \cdot g \cdot l_2)$

aus (F_x) $\rightarrow \quad \mu_h \frac{1}{l_1+l_2} T \cdot h_1 + \mu_h \frac{1}{l_1+l_2} m \cdot g \cdot l_2 - T = 0$

$$T\left(\frac{\mu_h h_1}{l_1 + l_2} - 1\right) = -\mu_h \frac{m \cdot g \cdot l_2}{l_1 + l_2} \rightarrow T = -\mu_h \frac{m \cdot g \cdot l_2}{l_1 + l_2} \frac{l_1 + l_2}{\mu_h h_1 - l_1 - l_2}$$

$$\underline{T} = -\mu_h \frac{m \cdot g \cdot l_2}{\mu_h h_1 - l_1 - l_2} = \underline{2786.93 N}$$

$$\underline{N_A} = \frac{T}{\mu_h} = \underline{5573.86 N}$$



Kiste: $\qquad \sum_i F_{y_i} = 0: \quad G_K - N_C = 0 \rightarrow N_C = G_K$

$\sum_i F_{x_i} = 0: \quad T - F_C = T - \mu_h' \cdot N_C = 0$

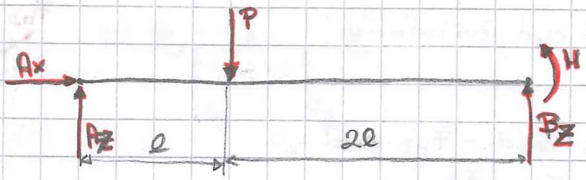
$$T - \mu_h' \cdot G_K = 0 \quad \rightarrow \quad \underline{G_K} = \frac{T}{\mu_h'} = \underline{6.97 kN}$$

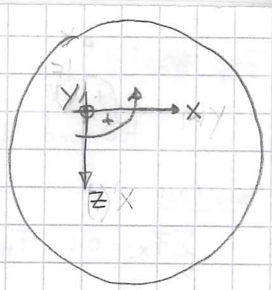
(b) Allrad: analog nur mit $F_B \neq 0$ (Haftreibungskr. um A & B nötig)

$\rightarrow \underline{G_K = 15.3 kN}$

29:

Auflagerreaktionen aus Gesamtsystem:





$\sum_i M_i^{(B)} = 0: \quad -P\cdot l + B_Z \cdot 3l + M = 0$

$\rightarrow B_Z = (P\cdot l - M)\frac{1}{3l}$

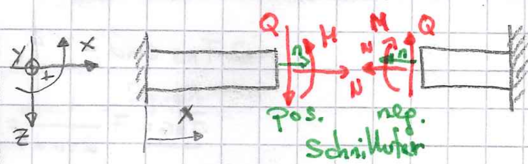
$\underline{\underline{B_Z}} = (8kN\cdot 2m - 40kNm)\frac{1}{3\cdot 2m} = \underline{\underline{-4kN}}$

$\sum_i F_{Z_i} = 0: \quad -A_Z + P - B_Z = 0$

$\rightarrow \underline{\underline{A_Z}} = P - B_Z = 8kN + 4kN = \underline{\underline{12kN}}$

$\sum_i F_{x_i} = 0: \quad \underline{\underline{A_x = 0}}$

Schnittufer, VZ-Konvention:



pos. SU: Normalenvektor zeigt in pos. x-Richtg.

neg. SU: ——— " ——— in neg. x-Richtg.

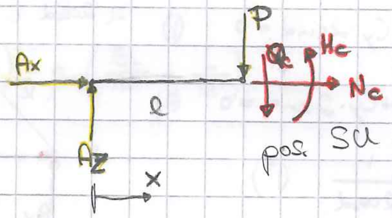
$\frac{dQ(x)}{dx} = -q(x) \rightarrow Q = -\int q(x)dx$

$Q_0 - \int q(x)dx$

$\frac{dM(x)}{dx} = Q(x) \rightarrow M = \int Q(x)dx$

Schnittgrößen an fixen Punkten:

Segment AC:



$\sum_i F_{x_i} = 0: \quad N_C + A_x = 0$

$\rightarrow N_C = 0$

$\sum_i F_{Z_i} = 0: \quad -A_Z + P + Q_C = 0$

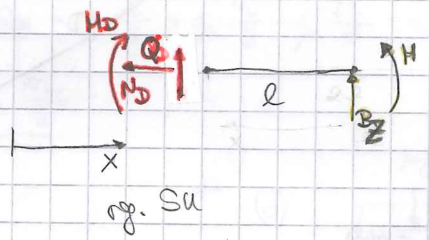
$\rightarrow Q_C = A_Z - P = 12kN - 8kN$

$\underline{\underline{Q_C = 4kN}}$

$\sum_i M_{C_i} = 0: \quad -A_Z\cdot l + M_C = 0$

$\rightarrow \underline{\underline{M_C}} = A_Z\cdot l = 12kN\cdot 2m = \underline{\underline{24kNm}}$

Segment BD:



$\sum_i F_{x_i} = 0: \quad N_D = 0$

$\sum_i F_{Z_i} = 0: \quad -Q_D - B_Z = 0$

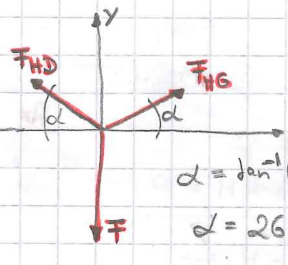
$\rightarrow \underline{\underline{Q_D}} = -B_Z = \underline{\underline{4kN}}$

$\sum_i M_{D_i} = 0: \quad -M_D + M + B_Z\cdot l = 0$

$\underline{\underline{M_D}} = M + B_Z\cdot l = 40kNm - 4kN\cdot 2m = \underline{\underline{32kNm}}$

Bsp. 30:

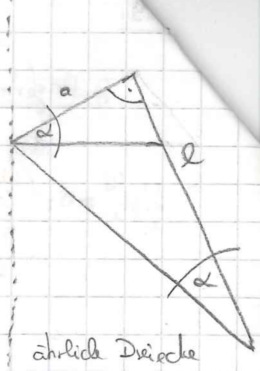
HD und HG sind Zweikraftstäbe!



$\alpha = \tan^{-1}\left(\frac{a}{l}\right)$

$\alpha = 26.57°$

(a)



ähnliche Dreiecke

aus (a):

$\sum_i F_{x_i} = 0: \quad F_{HG} \cdot \cancel{\cos\alpha} - F_{HD} \cdot \cancel{\cos\alpha} = 0$

$F_{HG} = F_{HD}$

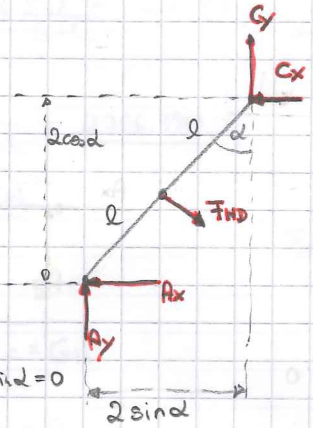
$\sum_i F_{y_i} = 0: \quad F_{HG} \cdot \sin\alpha + F_{HD} \cdot \sin\alpha - F = 0$

$2 \cdot F_{HG} \sin\alpha = F$

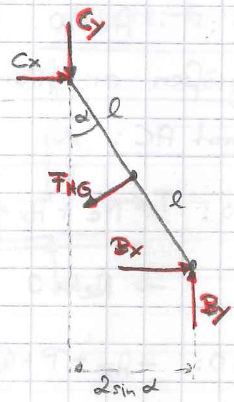
$\underline{F_{HG}} = F \frac{1}{2\sin\alpha} = \frac{800\,N}{2 \cdot \sin(26.57°)} = \underline{894\,N}$

$\underline{F_{HD} = 894\,N}$ (gerundet)

aus (b):



(b)



(c)

$\sum_i M_{A_i} = 0: \quad -F_{HD} \cdot l + C_x \cdot 2\cos\alpha + C_y \cdot 2\sin\alpha = 0 \quad (1)$

aus (c)

$\sum_i M_{B_i} = 0: \quad F_{HG} \cdot l - C_x \cdot 2\cos\alpha + C_y \cdot 2\sin\alpha = 0 \quad (2)$

aus (1) $\quad C_x = (F_{HD} \cdot l - C_y \cdot 2\sin\alpha) \frac{1}{2\cos\alpha} \quad (1^*)$

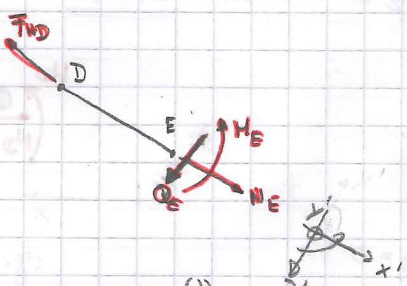
in (2) $\quad \underbrace{\cancel{F_{HG} \cdot l} - \cancel{\frac{F_{HD} \cdot l}{2\cos\alpha} 2\cos\alpha}}_{F_{HG} = F_{HD}} + \frac{C_y \cdot 2\sin\alpha}{\cancel{2\cos\alpha}} \cancel{2\cos\alpha} + C_y \cdot 2\sin\alpha = 0$

$4\, C_y \sin\alpha = 0 \rightarrow \underline{C_y = 0}$

in (1^*) $\quad C_x = F_{HD} \cdot l \frac{1}{2\cos\alpha} = 894\,N \cdot 1\,m \frac{1}{2\cos(26.57°)}$

$\underline{C_x = 500\,N}$ (gerundet)

Segment DE: (d)



(d)

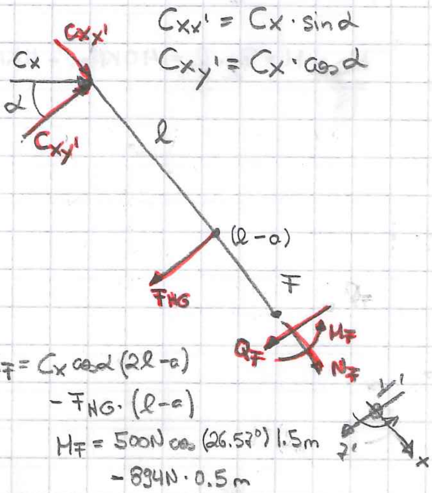
$\sum_i F_{z'_i} = 0: \quad + \underline{Q_E = 0}$

$\sum_i F_{x'_i} = 0: \quad -F_{HD} + N_E = 0$

$\rightarrow \underline{N_E} = F_{HD} = \underline{894\,N}$

$\sum_i M_{E_i} = 0: \quad \underline{M_E = 0}$

Segment CF: (e)



$C_{xx'} = C_x \cdot \sin\alpha$

$C_{xy'} = C_x \cdot \cos\alpha$

$\sum_i F_{z'_i} = 0: \quad Q_F + C_x \cdot \cos\alpha + F_{HG} = 0$

$\rightarrow Q_F = -F_{HG} + C_x \cos\alpha$

$= -894\,N + 500\,N \cdot \cos(26.57°)$

$\underline{Q_F = -447\,N}$

$\sum_i F_{x'_i} = 0: \quad N_F + C_x \cdot \sin\alpha = 0$

$\rightarrow \underline{N_F} = -C_x \cdot \sin\alpha = \underline{-224\,N}$

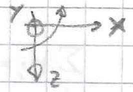
$\sum_i M_{F_i} = 0: \quad M_F + F_{HG} \cdot (l-a) - C_x \cos\alpha \cdot (2l-a) = 0$

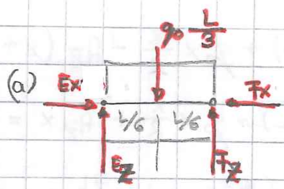
$M_F = C_x \cos\alpha\,(2l-a) - F_{HG} \cdot (l-a)$

$M_F = 500\,N \cos(26.57°)\, 1.5\,m - 894\,N \cdot 0.5\,m$

$\underline{M_F = 224\,Nm}$

3F:





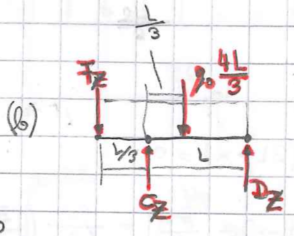
Segment EF

aus (a): $\sum_i M_i^{(E)} = 0: \; -F_Z \cdot \frac{\cancel{L}}{3} + q_0 \frac{\cancel{L}}{3}\frac{L}{6} = 0$

$\rightarrow \; F_Z = q_0 \frac{L}{6}$

$\sum_i F_{Z_i} = 0: \; -F_Z - E_Z + q_0 \frac{L}{3} = 0$

$\rightarrow \; E_Z = q_0 \frac{L}{3} - \underbrace{q_0 \frac{L}{6}}_{F_Z} = q_0 \frac{L}{6}$



Segment FCD

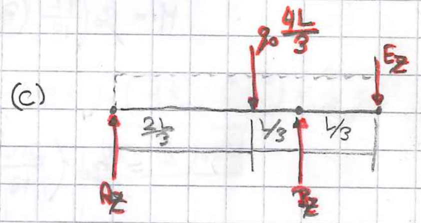
aus (b): $\sum_i M_{C_i} = 0: \; F_Z \cdot \frac{L}{3} - q_0 \frac{4L}{3}\frac{L}{3} + D_Z \cdot L = 0$

$D_Z = \left(-q_0 \frac{L}{6}\frac{\cancel{L}}{3} + q_0 \frac{4L}{3}\frac{\cancel{L}}{3}\right)\frac{1}{\cancel{L}}$

$D_Z = q_0 \left(\frac{4L}{9} - \frac{L}{18}\right) = q_0 \left(\frac{8L}{18} - \frac{L}{18}\right)$

$D_Z = q_0 \frac{7L}{18}$

Segment ABE



aus (c): $\sum_i M_{B_i} = 0: \; -A_Z \cdot \cancel{L} + q_0 \frac{4L}{3}\frac{\cancel{L}}{3} - E_Z \frac{\cancel{L}}{3} = 0$

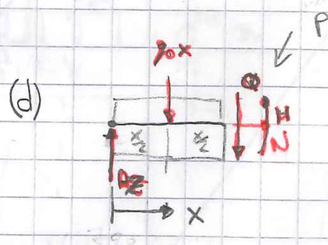
$A_Z = q_0 \frac{4L}{9} - q_0 \frac{L}{18} = q_0 \left(\frac{8L}{18} - \frac{L}{18}\right)$

$A_Z = q_0 \frac{7L}{18}$

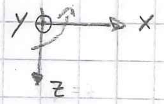
$\sum_i F_{Z_i} = 0: \; -A_Z + q_0 \frac{4L}{3} - B_Z + E_Z = 0$

$B_Z = E_Z + q_0 \frac{4L}{3} - A_Z = q_0 \frac{L}{6} + q_0 \frac{4L}{3} - q_0 \frac{7L}{18} = q_0 \left(\frac{3L}{18} + \frac{24L}{18} - \frac{7L}{18}\right)$

$B_Z = q_0 \frac{20L}{18} = q_0 \frac{10L}{9}$



zwischen A & B



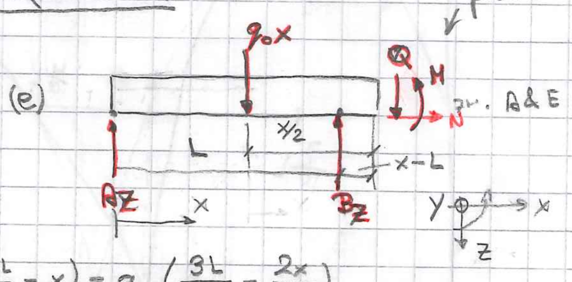
aus (d): $\boxed{0 \leq x < L}$

$\sum_i F_{Z_i} = 0: \; -A_Z + q_0 x + Q = 0$

$Q = -q_0 x + q_0 \frac{7L}{18} \rightarrow Q(x) = \frac{q_0}{18}(7L - 18x)$

$\sum_i M_i = 0: \; M + q_0 x \cdot \frac{x}{2} - A_Z \cdot x = 0$

$M(x) = A_Z \cdot x - q_0 \frac{x^2}{2} = q_0 \frac{7L}{18} x - q_0 \frac{x^2}{2} = \frac{q_0}{18}(7Lx - 9x^2)$



aus (e): $\boxed{L \leq x \leq 2L}$

$\sum_i F_{Z_i} = 0: \; -A_Z + q_0 x - B_Z + Q = 0$

$Q = A_Z - q_0 x + B_Z = q_0 \frac{7L}{18} - q_0 x + q_0 \frac{10L}{9}$

$Q(x) = q_0 \left(\frac{7L}{18} - x + \frac{20L}{18}\right) = q_0 \left(\frac{27L}{18} - x\right) = q_0 \left(\frac{3L}{2} - \frac{2x}{2}\right)$

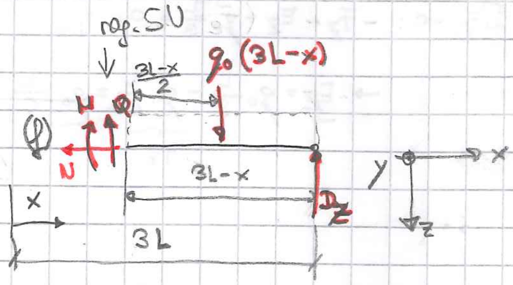
$Q(x) = \frac{q_0}{2}(3L - 2x)$

$$\sum_i M_i = 0: \quad M - B_Z \cdot (x-L) + q_0 x \frac{x}{2} - A_Z(\cancel{L} + x - \cancel{L}) = 0$$

$$M = B_Z(x-L) - q_0 x \frac{x}{2} + A_Z x = q_0 \frac{10L}{9}(x-L) - q_0 x \frac{x}{2} + q_0 \frac{7L}{18} x$$

$$M = q_0\left(\frac{10L}{9}(x-L) + \frac{7L}{18}x - q_0 x \frac{x}{2}\right) = q_0\left(\frac{10L}{9}x + \frac{7L}{18}x - \frac{10L^2}{9} - q_0\frac{x^2}{2}\right)$$

$$\underline{M(x) = \frac{q_0}{18}\left(27Lx - 20L^2 - 9x^2\right)}$$



aus (f) $2L < x \leq 3L$:

$$\sum_i F_{Z_i} = 0: \quad -Q - D_Z + q_0(3L - x) = 0$$

$$Q = q_0\left[(3L-x) - \frac{7L}{18}\right] = \frac{q_0}{18}\left(\frac{54L}{18} - \frac{7L}{18} - \frac{18x}{18}\right)$$

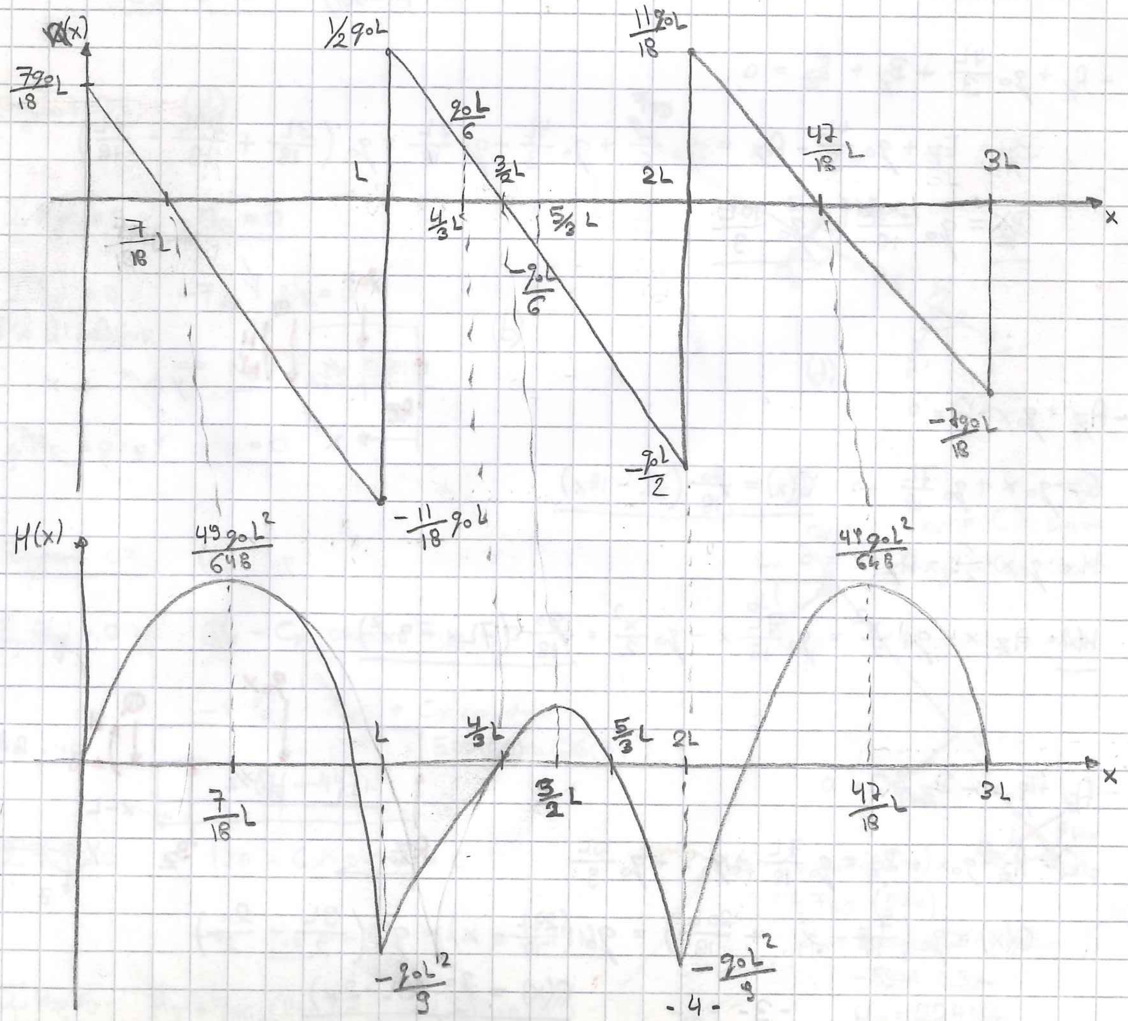
$$\underline{Q(x) = \frac{q_0}{18}\left(47L - 18x\right)}$$

$$\sum_i M_i = 0: \quad -M - q_0(3L-x)\frac{3L-x}{2} + D_Z(3L-x) = 0$$

$$M = q_0\left(\frac{7L}{18}(3L-x) - (3L-x)\frac{3L-x}{2}\right) = q_0\left(\frac{21L^2}{18} - \frac{9L^2}{2} - \frac{7Lx}{18} + \frac{3Lx}{2} + \frac{3Lx}{2} - \frac{x^2}{2}\right)$$

$$= q_0\left(\frac{21L^2}{18} - \frac{81L^2}{18} - \frac{7Lx}{18} + \frac{54Lx}{18} - \frac{9x^2}{18}\right)$$

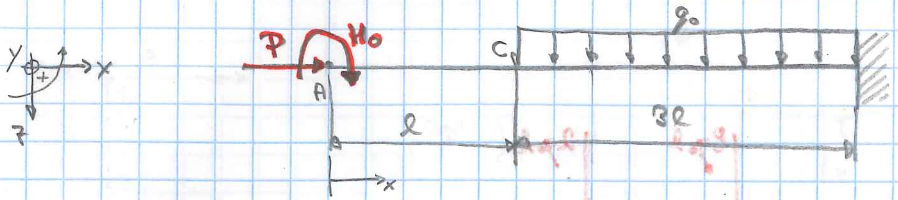
$$\underline{M(x) = \frac{q_0}{18}\left(47Lx - 9x^2 - 60L^2\right)}$$



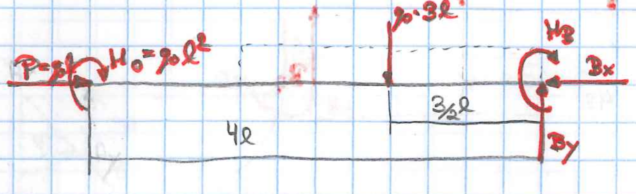
Bsp. 32:

Gegeben: $q_0,\ l,\ P = q_0 l,\ M_0 = q_0 l^2$

Gesucht: Auflagerreaktion in B, Schnittgrößen $Q(x)$, $M(x)$



Freikörperbild:



Statik:

$\sum F_{x_i} = 0: \quad q_0 l - B_x = 0 \quad \rightarrow \quad \boxed{B_x = q_0 l}$

$\sum F_{y_i} = 0: \quad B_z - 3 q_0 l = 0 \quad \rightarrow \quad \boxed{B_z = 3 q_0 l}$

$\sum M_i^{(B)} = 0: \quad -M_B + q_0 \cdot 3l \frac{3}{2} l - q_0 l^2 = 0 \quad \rightarrow \quad M_B = q_0 \left(\frac{9}{2} l^2 - \frac{2}{2} l^2\right) = \frac{7}{2} q_0 l^2$

$\boxed{M_B = \frac{7}{2} q_0 l^2}$

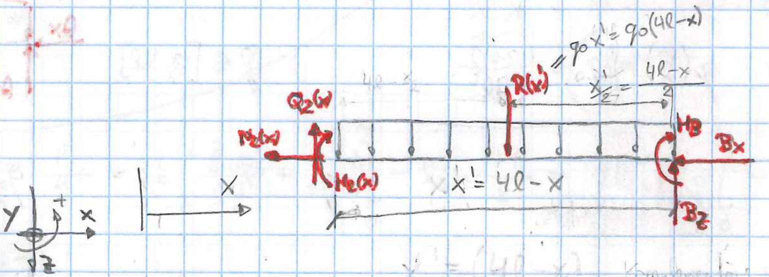
$0 \leq x \leq l$:

$\boxed{Q_1(x) = 0}$

$N_1(x) = -q_0 l$

$\boxed{M_1(x) = q_0 l^2}$

$l \leq x \leq 4l$:



$N_2(x) = -B_x = -q_0 l$

$Q_2(x) = -B_z + R(x) = -3 q_0 l + q_0 (4l - x) \quad \rightarrow \quad \boxed{Q_2(x) = q_0 (l - x)}$

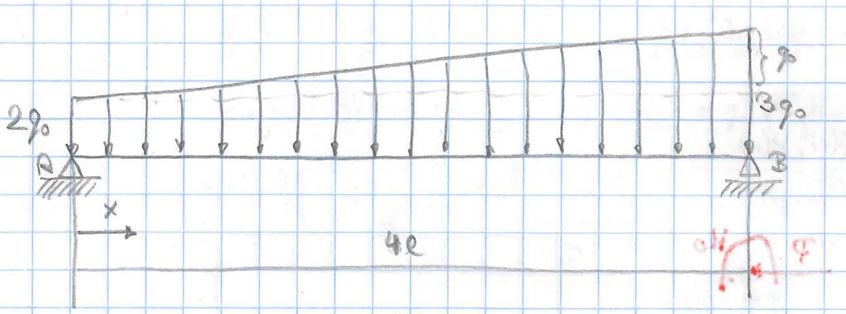
$M_2(x) = -M_B - R(x) \cdot (4l - x) \frac{1}{2} + B_z \cdot (4l - x) = -\frac{7}{2} q_0 l^2 - \frac{q_0}{2} (4l - x)^2 + 3 q_0 l (4l - x)$

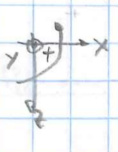
$= -\frac{7}{2} q_0 l^2 - \frac{q_0}{2} (16 l^2 - 8 l x + x^2) + 12 q_0 l^2 - 3 q_0 l x$

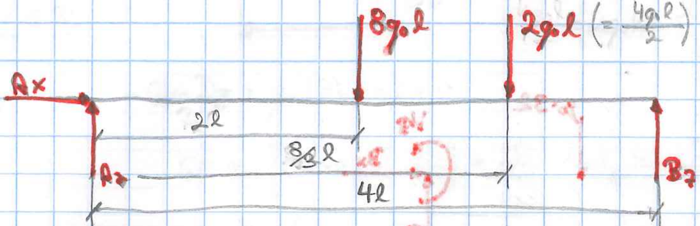
$= \frac{q_0}{2} (-7 l^2 - 16 l^2 + 8 l x - x^2 + 24 l^2 - 6 l x)$

$\boxed{M_2(x) = \frac{q_0}{2} (l^2 + 2 l x - x^2)}$

Bsp. 33:







Auflager:

$$\sum_i F_{x_i} = 0: \quad A_x = 0 \qquad (1)$$

$$\sum_i F_{y_i} = 0: \quad A_z - 8q_0 l - 2q_0 l + B_z = 0 \qquad (2)$$

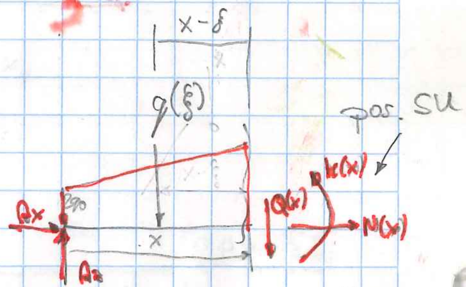
$$\sum_i M_i^{(A)} = 0: \quad -8q_0 l \cdot 2l - 2q_0 l \cdot \frac{8}{3} l + B_z \cdot 4l = 0 \qquad (3)$$

aus (3): $\underline{B_z} = \left(16 q_0 l + \frac{16}{3} q_0 l\right)\frac{1}{4} = \underline{\underline{\frac{16}{3} q_0 l}}$

aus (1): $\underline{\underline{A_x = 0}}$

aus (2): $\underline{\underline{A_z}} = 10 q_0 l - \frac{16}{3} q_0 l = \underline{\underline{\frac{14}{3} q_0 l}}$

Schnittgrößen: (Integral):



Streckenlast: $q(\xi) = \underbrace{2q_0}_{d} + \underbrace{\frac{q_0}{4l}}_{k}\underbrace{\xi}_{x} \qquad \xi \in [0, 4l]$

$$Q(x) = \underbrace{A_z}_{Q(0)} - \int_0^x q(\xi)\,d\xi = \frac{14}{3} q_0 l - \int_0^x \left(2q_0 + \frac{q_0 \xi}{4l}\right) d\xi = \frac{14}{3} q_0 l - \left(2q_0 \xi + \frac{q_0 \xi^2}{8l}\right)\Bigg|_0^x$$

$$= \frac{14}{3} q_0 l - 2q_0 x - \frac{q_0 x^2}{8l} \qquad \underline{\underline{Q(x) = q_0\left[\frac{14}{3} l - 2x - \frac{x^2}{8l}\right]}}$$

$$M(x) = \int_0^x Q(\xi)\,d\xi = \int_0^x q_0\left[\frac{14}{3} l - 2\xi - \frac{\xi^2}{8l}\right] d\xi$$

$$= q_0\left[\frac{14}{3} l \xi - 2\frac{\xi^2}{2} - \frac{\xi^3}{24l}\right]\Bigg|_0^x \qquad \underline{\underline{M(x) = q_0\left[\frac{14}{3} lx - x^2 - \frac{x^3}{24l}\right]}}$$

(oder: $M(x) = A_z \cdot x - \int_0^x q(\xi)\cdot(x-\xi)\,d\xi = A_z \cdot x - \int_0^x \left(2q_0 x - 2q_0 \xi + \frac{q_0 x}{4l}\xi - \frac{q_0}{4l}\xi^2\right) d\xi$

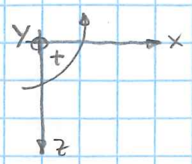
$$= \frac{14}{3} q_0 l x - \left[2q_0 x \xi - 2q_0 \frac{\xi^2}{2} + \frac{q_0 x}{4l}\frac{\xi^2}{2} - \frac{q_0}{4l}\frac{\xi^3}{3}\right]\Bigg|_0^x$$

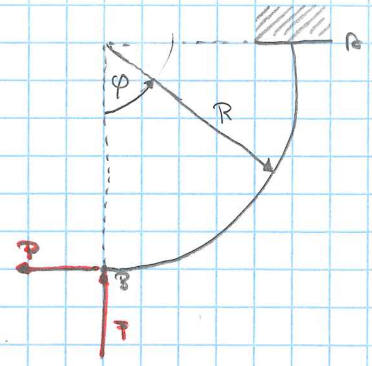
$$= \frac{14}{3} q_0 l x \underbrace{- 2q_0 x^2 + q_0 x^2}_{-q_0 x^2} \underbrace{- \frac{q_0 x^3}{8l} + \frac{q_0 x^3}{12l}}_{-\frac{q_0 x^3}{24l}} \rightarrow \underline{\underline{M(x) = q_0\left[\frac{14}{3} lx - x^2 - \frac{x^3}{24l}\right]}}\ )$$

Bsp. 34:

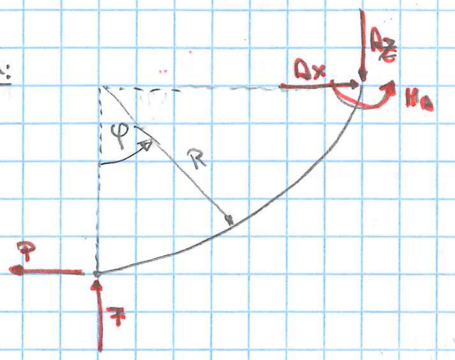
Gegeben: R, F, P

Gesucht: Einspannreaktionen in A, Schnittgrößen $N(\varphi), Q(\varphi), M(\varphi)$





Freikörperbild:



Statik:

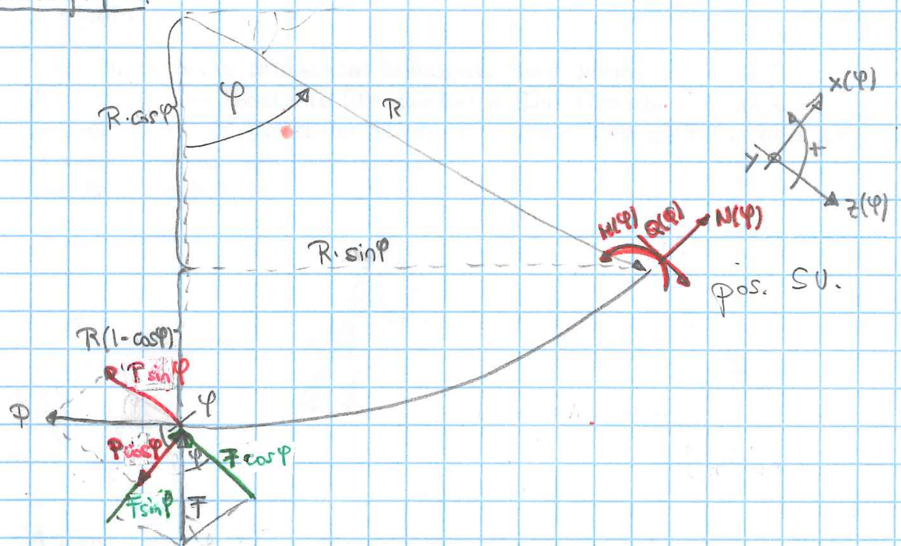
$\sum F_{x_i} = 0: \quad A_x - P = 0 \rightarrow \boxed{A_x = P}$

$\sum F_{z_i} = 0: \quad +A_z + F = 0 \rightarrow \boxed{A_z = F}$

$\sum M_i^{(A)} = 0: \quad M_A - F \cdot R - P \cdot R = 0$

$\rightarrow \boxed{M_A = (F+P)R}$

Schnittgrößen:



$$\boxed{\begin{aligned} N(\varphi) &= P\cos\varphi - F\sin\varphi \\ Q(\varphi) &= P\sin\varphi + F\cos\varphi \\ M(\varphi) &= F R\sin\varphi + P R(1-\cos\varphi) \end{aligned}}$$

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