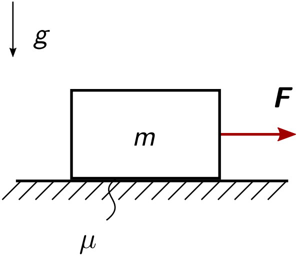
Reibung und Seilreibung

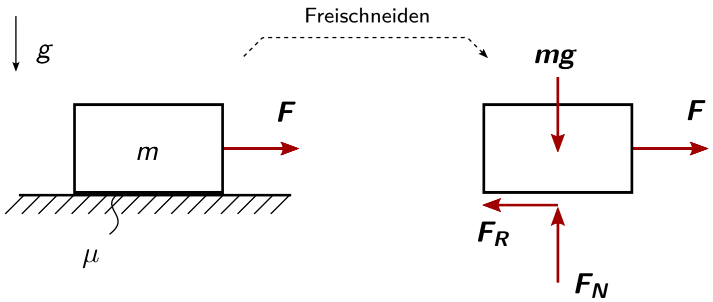
Dominik Zobel

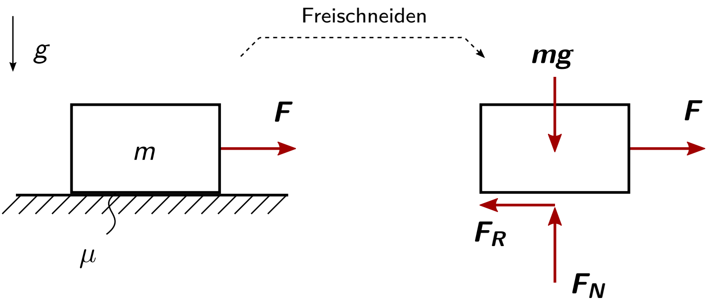
- Haftreibung
- Reibkegel
- Beispiel Reibblock
- Seilreibung
- Aufgabe Seilreibung
- Aufgabe Reibung

Haftreibung Block



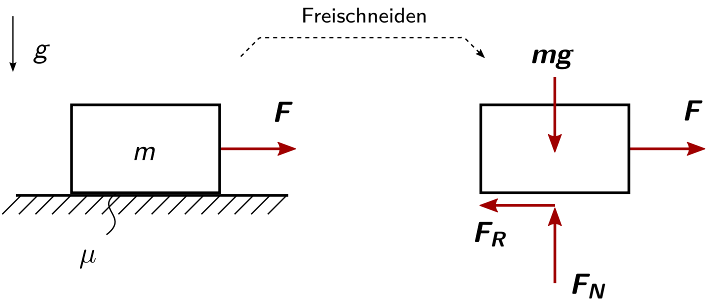
Haftreibung Block





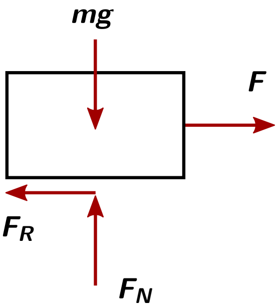
$$|\boldsymbol{F_R}| \leq \mu |\boldsymbol{F_N}|$$

Haftreibung Block



$$|\boldsymbol{F_R}| \leq \mu |\boldsymbol{F_N}|$$

$$|\boldsymbol{F}_{\boldsymbol{R},\text{max}}| = \mu |\boldsymbol{F_N}|$$



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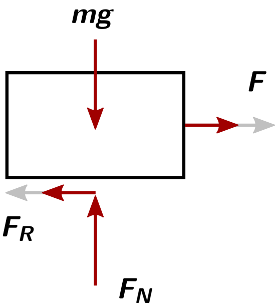
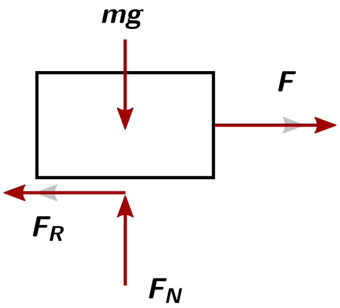


$$|F_R| \leq \mu |F_N|$$

$$|F_{R,\max}| = \mu |F_N|$$

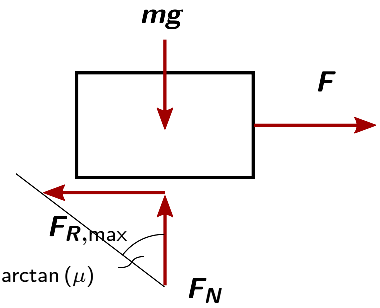
Reibkegel



$$|\boldsymbol{F_R}| \leq \mu |\boldsymbol{F_N}|$$

$$|\boldsymbol{F_{R,\text{max}}}| = \mu |\boldsymbol{F_N}|$$

Reibkegel



$$|F_R| \leq \mu |F_N|$$

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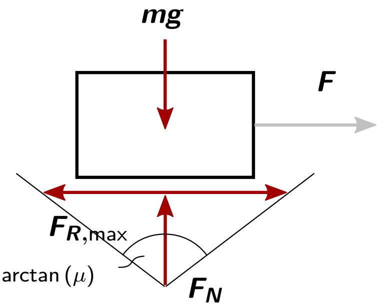
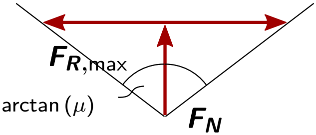
Reibkegel



$$|F_R| \leq \mu |F_N|$$

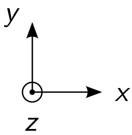
$$|F_{R,\max}| = \mu |F_N|$$

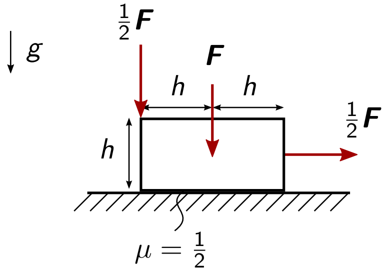
Reibkegel



$\mu = \frac{F_{R,\text{max}}}{F_N}$ ist die Steigung des Reibkegels

Gegeben: g, h, F, μ

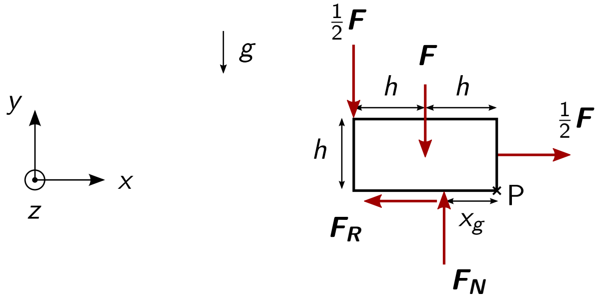




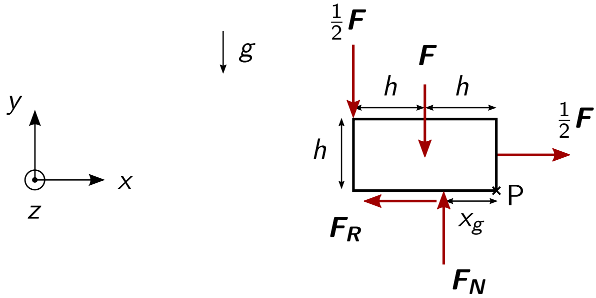
a) Freikörperbild zeichnen

b) Betrag und Angriffspunkt der Normalkraft $\boldsymbol{F_N}$ bestimmen

Gegeben: g, h, F, μ

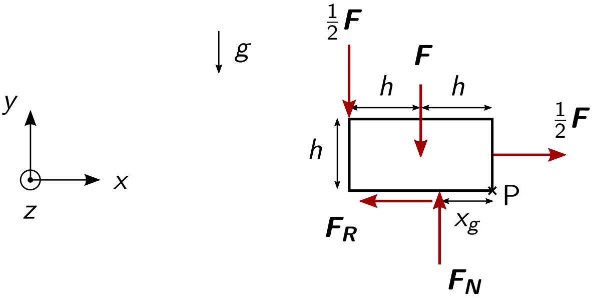


Gegeben: g, h, F, μ



$$\sum M^P \ : \ 0 = -x_g F_N - \frac{h}{2}\frac{1}{2}F + hF + 2h\frac{1}{2}F$$

Gegeben: g, h, F, μ

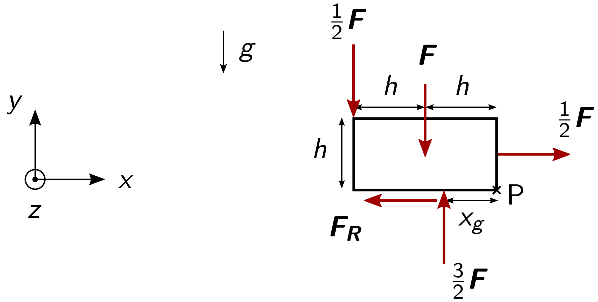


$$\sum M^P \; : \; 0 = -x_g F_N - \frac{h}{2}\frac{1}{2}F + hF + 2h\frac{1}{2}F$$

$$\sum F_y \; : \; 0 = -F - \frac{1}{2}F + F_N \quad \Rightarrow \quad F_N = \frac{3}{2}F$$

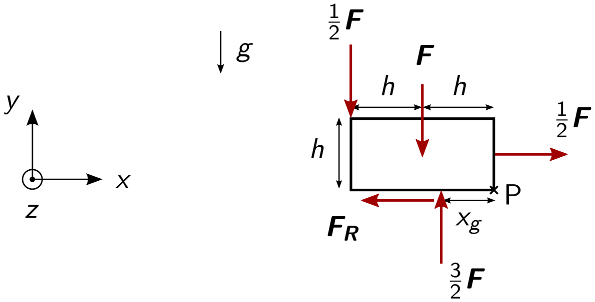
Beispiel zum Reibblock

Gegeben: g, h, F, μ



$$\sum \boldsymbol{M^P} \; : \; 0 = -x_g \boldsymbol{F_N} - \frac{h}{2}\frac{1}{2}\boldsymbol{F} + h\boldsymbol{F} + 2h\frac{1}{2}\boldsymbol{F}$$

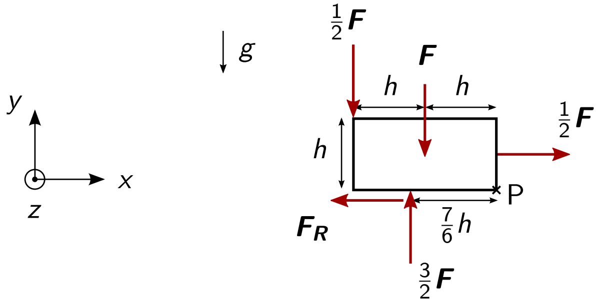
Gegeben: g, h, F, μ



$$\sum M^P \;:\; 0 = -x_g F_N - \frac{h}{2}\frac{1}{2}F + hF + 2h\frac{1}{2}F$$

$$0 = -x_g \frac{3}{2}F + \frac{7}{4}hF \quad \Rightarrow \quad x_g = \frac{7}{6}h$$

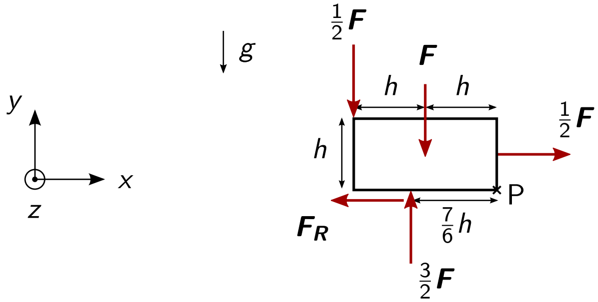
Gegeben: g, h, F, μ



$$|\boldsymbol{F_R}| \leq \mu |\boldsymbol{F_N}| \qquad |\boldsymbol{F_{R,\mathrm{max}}}| = \mu |\boldsymbol{F_N}|$$

Beispiel zum Reibblock

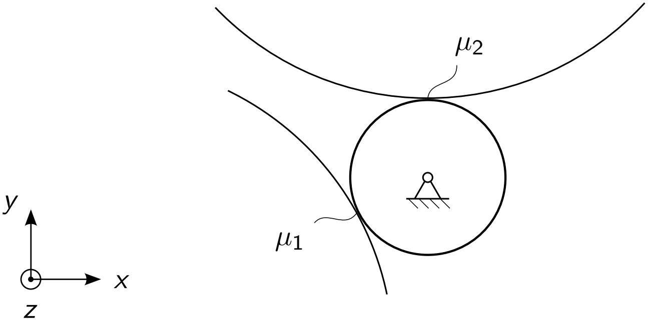
Gegeben: g, h, F, μ



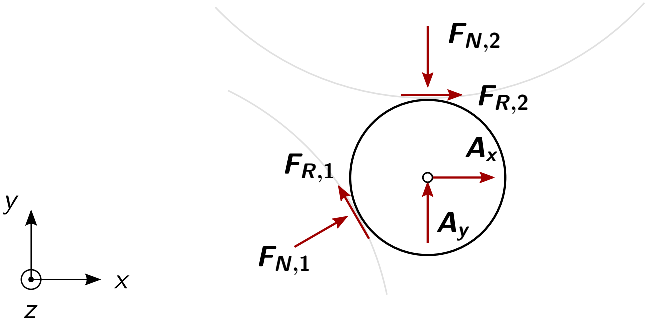
$$|\boldsymbol{F_R}| \leq \mu |\boldsymbol{F_N}| \qquad |\boldsymbol{F_{R,\text{max}}}| = \mu |\boldsymbol{F_N}|$$

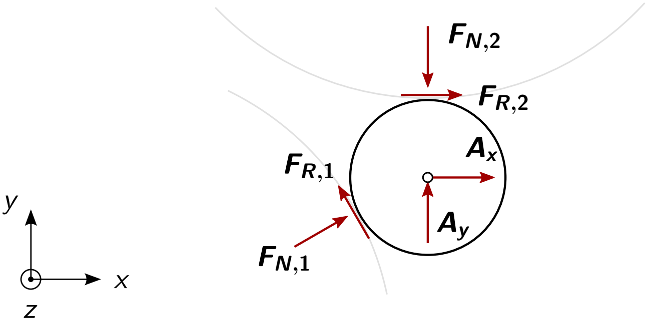
$$\boldsymbol{F_N} = \frac{3}{2}\boldsymbol{F} \quad \Rightarrow \quad \boldsymbol{F_{R,\text{max}}} = \frac{3}{4}\boldsymbol{F} \quad , \quad \boldsymbol{F_R} = \frac{1}{2}\boldsymbol{F}$$

Reibzylinder

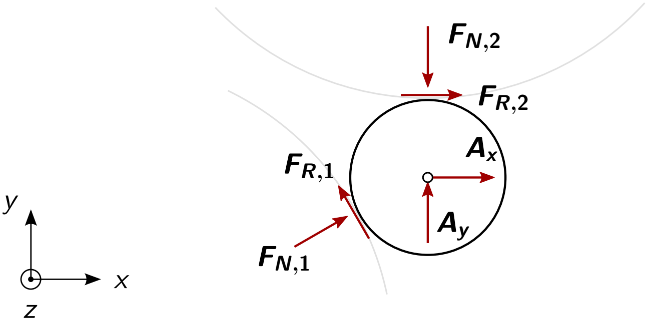


Reibzylinder





F_R entgegen Bewegungsrichtung annehmen



$\boldsymbol{F_R}$ entgegen Bewegungsrichtung annehmen

Bei Zylindern $\boldsymbol{F_{R,i}}$ in gleiche Drehrichtung annehmen

Gleitreibung findet statt, wenn Haftreibung überwunden ist

Gleitreibung

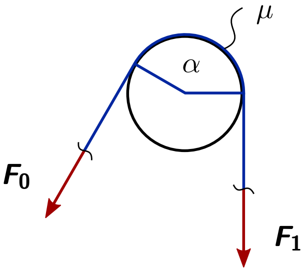
Gleitreibung findet statt, wenn Haftreibung überwunden ist

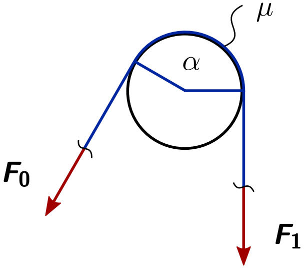
$$|\boldsymbol{F_R}| = \mu_G |\boldsymbol{F_N}|$$

Gleitreibung findet statt, wenn Haftreibung überwunden ist

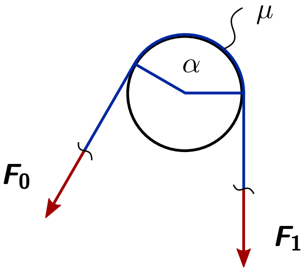
$$|\boldsymbol{F_R}| = \mu_G |\boldsymbol{F_N}|$$

$$\mu_G < \mu_{(H)}$$


μ
α
F_0
F_1

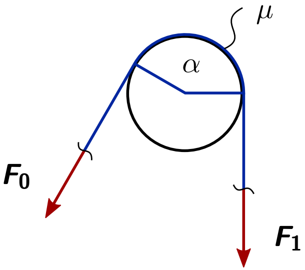


Eytelweinsche Gleichung $\frac{|F_1|}{|F_0|} = e^{\mu\alpha}$



Eytelweinsche Gleichung $\frac{|F_1|}{|F_0|} = e^{\mu\alpha}$

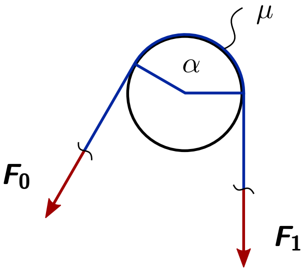
Es gilt $e^{-x} = \frac{1}{e^x}$ und $e^0 = 1$



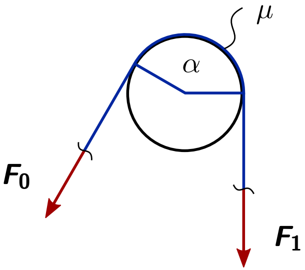
Eytelweinsche Gleichung $\frac{|F_1|}{|F_0|} = e^{\mu\alpha}$

Es gilt $e^{-x} = \frac{1}{e^x}$ und $e^0 = 1$

Dicke des Zylinders ist egal, nur Auflagewinkel von Bedeutung



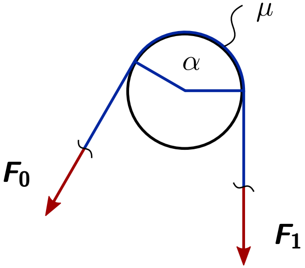
F_0 bewegt das Seil zu sich | **nichts bewegt sich** | F_1 bewegt das Seil zu sich



F_0 bewegt das Seil zu sich	**nichts bewegt sich**	F_1 bewegt das Seil zu sich

$|F_1| = |F_0|$

Seilreibung

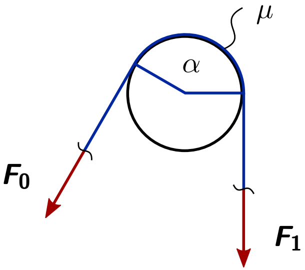


$|\boldsymbol{F}_1| = |\boldsymbol{F}_0|$

$\boldsymbol{F}_0$ bewegt das Seil zu sich	**nichts bewegt sich**	$\boldsymbol{F}_1$ bewegt das Seil zu sich

$|\boldsymbol{F}_1| < |\boldsymbol{F}_0|$ | $|\boldsymbol{F}_1| > |\boldsymbol{F}_0|$

Seilreibung



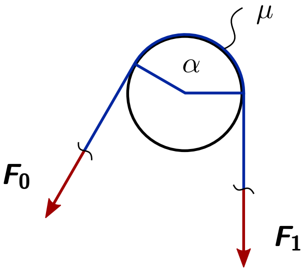
$|\boldsymbol{F}_1| = |\boldsymbol{F}_0|$ $\quad$ $|\boldsymbol{F}_1| > e^{\mu\alpha}|\boldsymbol{F}_0|$

$\boldsymbol{F}_0$ bewegt das Seil zu sich | **nichts bewegt sich** | $\boldsymbol{F}_1$ bewegt das Seil zu sich

$|\boldsymbol{F}_1| < |\boldsymbol{F}_0|$ $\quad$ $|\boldsymbol{F}_1| > |\boldsymbol{F}_0|$

$|\boldsymbol{F}_1| = e^{\mu\alpha}|\boldsymbol{F}_0|$

Seilreibung



$|F_1| < e^{-\mu\alpha}|F_0|$ — F_0 bewegt das Seil zu sich

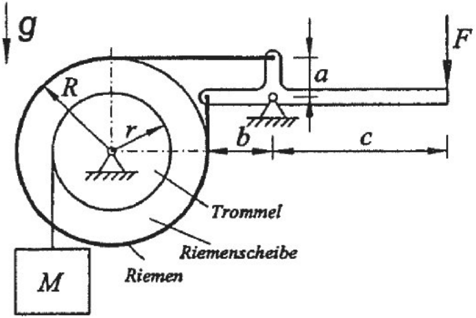
$|F_1| = e^{-\mu\alpha}|F_0|$

nichts bewegt sich: $|F_1| < |F_0|$, $|F_1| = |F_0|$, $|F_1| > |F_0|$

$|F_1| = e^{\mu\alpha}|F_0|$

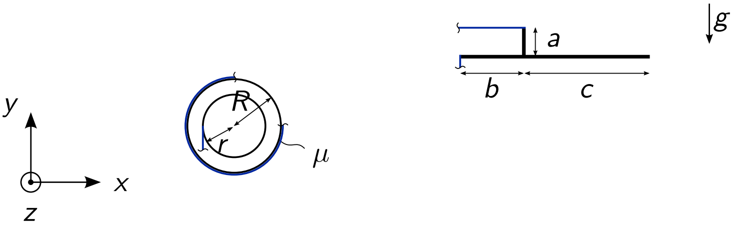
$|F_1| > e^{\mu\alpha}|F_0|$ — F_1 bewegt das Seil zu sich

H06 – Aufgabe 4



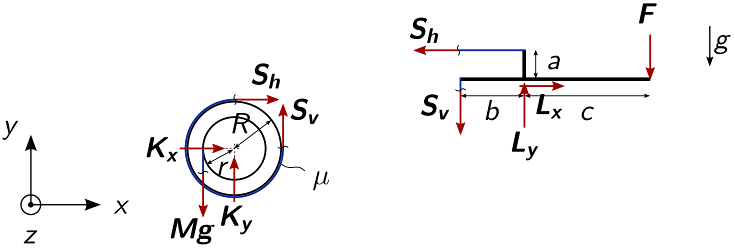
a) Freikörperbild

Gegeben: g ; μ ; a ; b ; c ; r ; R ; M



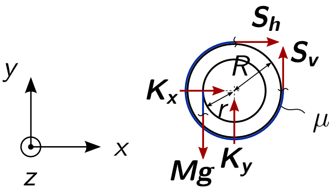
a) Freikörperbild

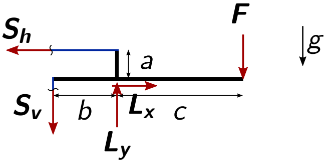
Gegeben: g ; μ ; a ; b ; c ; r ; R ; M



b) Erforderliche Gleichungen, um $\boldsymbol{F}$ zu bestimmen

Gegeben: g ; μ ; a ; b ; c ; r ; R ; M





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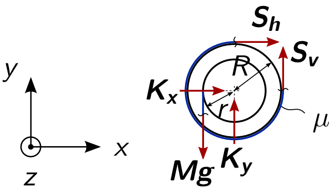
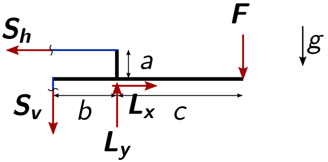


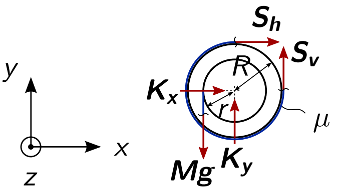


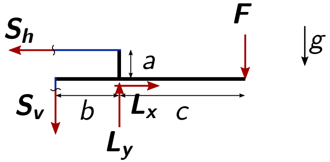
$$\sum M_z^K \;:\; 0 = r\boldsymbol{Mg} - R\boldsymbol{S_h} + R\boldsymbol{S_v}$$

H06–4

b) Erforderliche Gleichungen, um $\boldsymbol{F}$ zu bestimmen

Gegeben: g ; μ ; a ; b ; c ; r ; R ; M



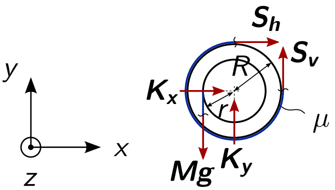


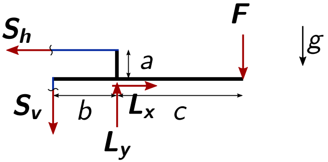
$$\sum M_z^K \; : \; 0 = r\boldsymbol{Mg} - R\boldsymbol{S_h} + R\boldsymbol{S_v}$$

$$\boldsymbol{S_h} = \boldsymbol{S_v} + \frac{r}{R}\boldsymbol{Mg}$$

b) Erforderliche Gleichungen, um $\boldsymbol{F}$ zu bestimmen

Gegeben: g ; μ ; a ; b ; c ; r ; R ; M





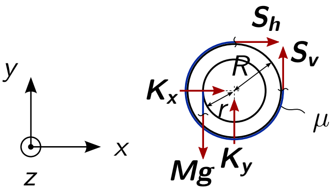
$$\sum \boldsymbol{M}_z^K \;:\; 0 = r\boldsymbol{Mg} - R\boldsymbol{S_h} + R\boldsymbol{S_v}$$

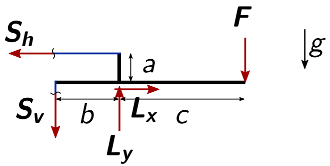
$$\boldsymbol{S_h} = \boldsymbol{S_v} + \frac{r}{R}\boldsymbol{Mg}$$

$$\boldsymbol{S_h} = \boldsymbol{S_v} e^{\frac{3}{2}\pi\mu}$$

b) Erforderliche Gleichungen, um $\boldsymbol{F}$ zu bestimmen

Gegeben: g ; μ ; a ; b ; c ; r ; R ; M





$$\sum M_z^K \ : \ 0 = r\boldsymbol{Mg} - R\boldsymbol{S_h} + R\boldsymbol{S_v}$$

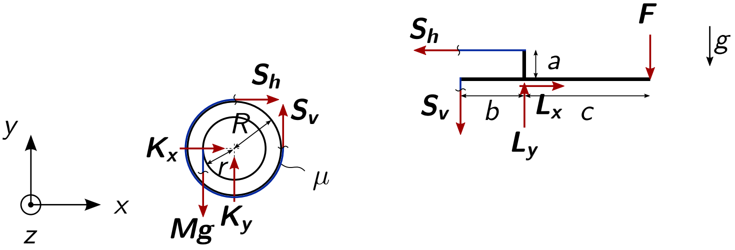
$$\boldsymbol{S_h} = \boldsymbol{S_v} + \frac{r}{R}\boldsymbol{Mg}$$

$$\boldsymbol{S_h} = \boldsymbol{S_v} e^{\frac{3}{2}\pi\mu}$$

$$\sum M_z^L \ : \ 0 = b\boldsymbol{S_v} + a\boldsymbol{S_h} - c\boldsymbol{F}$$

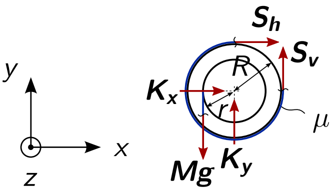
c) $\boldsymbol{F}$ in gegebenen Größen angeben

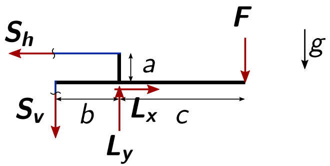
Gegeben: g ; μ ; a ; b ; c ; r ; R ; M



c) $\boldsymbol{F}$ in gegebenen Größen angeben

Gegeben: g ; μ ; a ; b ; c ; r ; R ; M

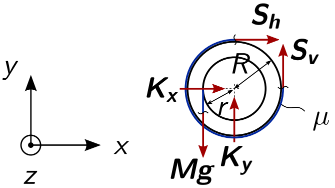


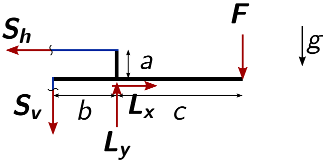


$$S_v = \frac{r}{R} \cdot \frac{Mg}{e^{\mu \frac{3}{2}\pi} - 1}$$

c) $\boldsymbol{F}$ in gegebenen Größen angeben

Gegeben: g ; μ ; a ; b ; c ; r ; R ; M



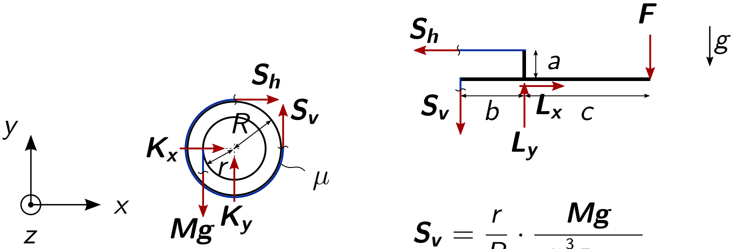


$$\boldsymbol{S_v} = \frac{r}{R} \cdot \frac{\boldsymbol{Mg}}{e^{\mu \frac{3}{2}\pi} - 1}$$

$$\boldsymbol{S_h} = \frac{r}{R} \cdot \frac{\boldsymbol{Mg}\, e^{\frac{3}{2}\pi\mu}}{e^{\frac{3}{2}\pi\mu} - 1}$$

c) $\boldsymbol{F}$ in gegebenen Größen angeben

Gegeben: g ; μ ; a ; b ; c ; r ; R ; M



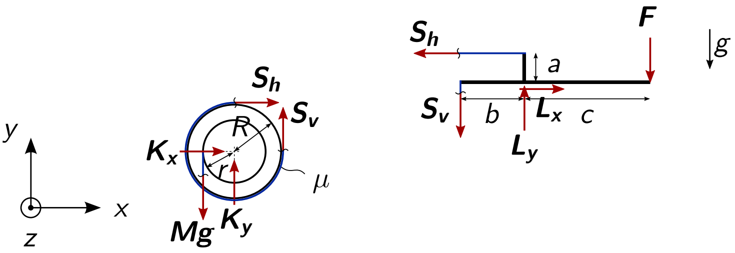
$$\boldsymbol{S_v} = \frac{r}{R} \cdot \frac{\boldsymbol{Mg}}{e^{\mu\frac{3}{2}\pi} - 1}$$

$$\boldsymbol{S_h} = \frac{r}{R} \cdot \frac{\boldsymbol{Mg}\, e^{\frac{3}{2}\pi\mu}}{e^{\frac{3}{2}\pi\mu} - 1}$$

$$\boldsymbol{F} = \frac{r}{cR} \cdot \frac{\boldsymbol{Mg}}{e^{\frac{3}{2}\pi\mu} - 1}\left(b + a e^{\frac{3}{2}\pi\mu}\right)$$

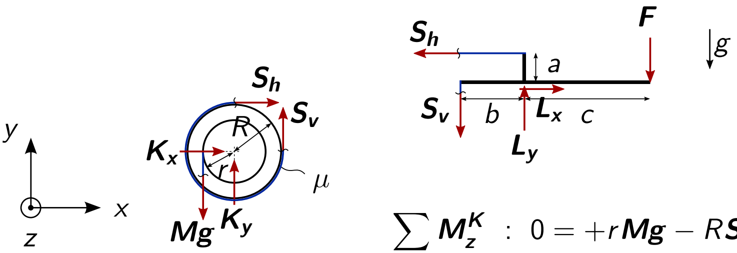
d) $\boldsymbol{F}$ berechnen, wenn $\boldsymbol{Mg}$ auf der anderen Seite angreift

Gegeben: g ; μ ; a ; b ; c ; r ; R ; M



d) $\boldsymbol{F}$ berechnen, wenn $\boldsymbol{Mg}$ auf der anderen Seite angreift

Gegeben: g ; μ ; a ; b ; c ; r ; R ; M

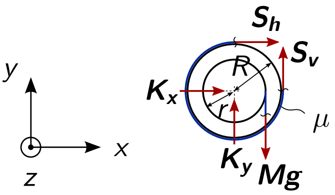


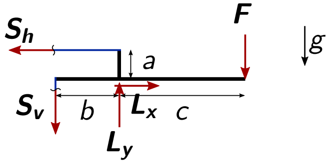
$$\sum M_z^K : \ 0 = +r\boldsymbol{Mg} - R\boldsymbol{S_h} + R\boldsymbol{S_v}$$

$$\boldsymbol{S_h} = \boldsymbol{S_v} e^{+\frac{3}{2}\pi\mu}$$

d) ***F*** berechnen, wenn ***Mg*** auf der anderen Seite angreift

Gegeben: g ; μ ; a ; b ; c ; r ; R ; M





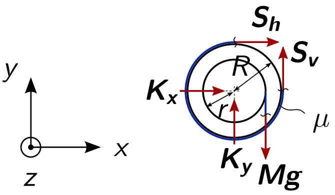
$$\sum M_z^K \;:\; 0 = -r\boldsymbol{Mg} - R\boldsymbol{S_h} + R\boldsymbol{S_v}$$

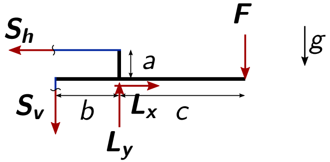
$$\boldsymbol{S_h} = \boldsymbol{S_v} e^{-\frac{3}{2}\pi\mu}$$

H06–4

d) $\boldsymbol{F}$ berechnen, wenn $\boldsymbol{Mg}$ auf der anderen Seite angreift

Gegeben: $g\ ;\ \mu\ ;\ a\ ;\ b\ ;\ c\ ;\ r\ ;\ R\ ;\ M$



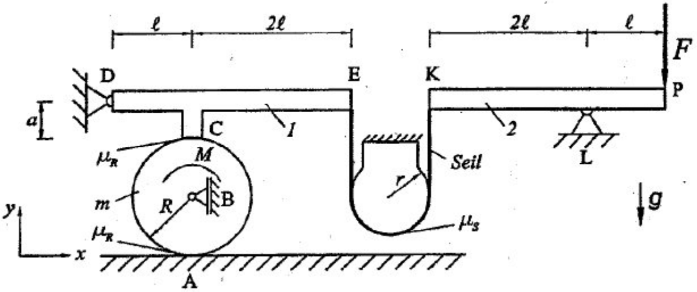


$$\sum M_z^K\ :\ 0 = -r\boldsymbol{Mg} - R\boldsymbol{S_h} + R\boldsymbol{S_v}$$

$$\boldsymbol{S_h} = \boldsymbol{S_v} e^{-\frac{3}{2}\pi\mu}$$

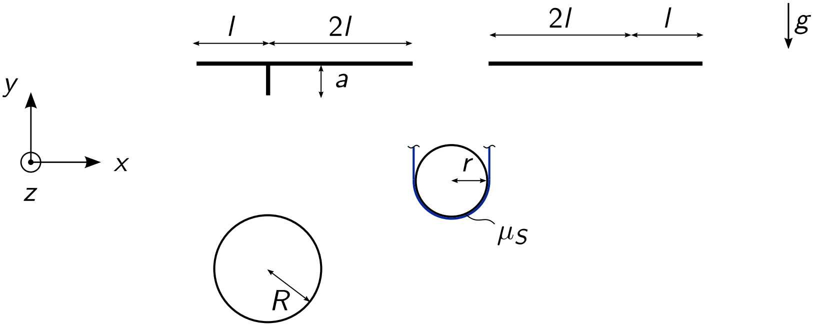
$$\boldsymbol{F} = \frac{r}{cR} \cdot \frac{\boldsymbol{Mg}}{e^{-\frac{3}{2}\pi\mu} - 1} \left(b + a e^{-\frac{3}{2}\pi\mu}\right)$$

H07 – Aufgabe 3



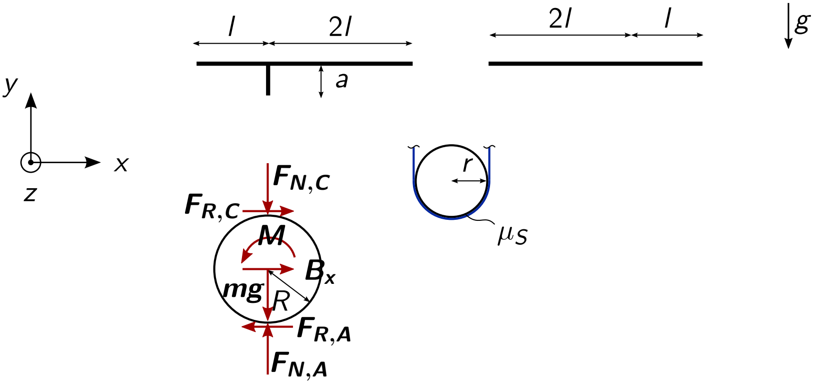
a) Freikörperbild

Gegeben: g ; m ; M ; R ; r ; l ; a ; μ_S ; μ_R



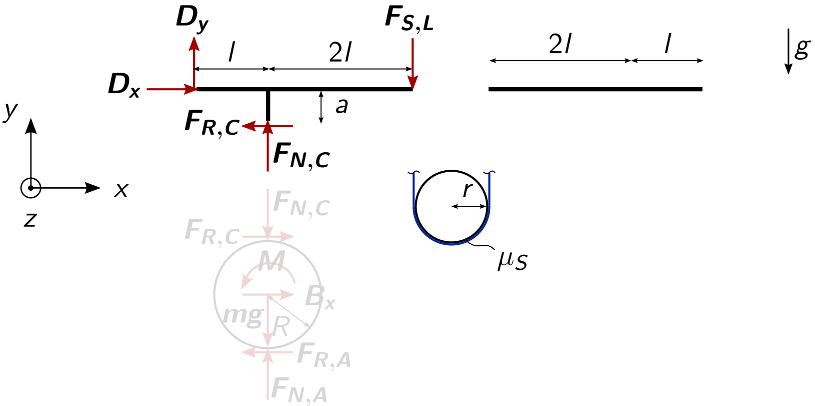
a) Freikörperbild

Gegeben: g ; m ; M ; R ; r ; l ; a ; μ_S ; μ_R



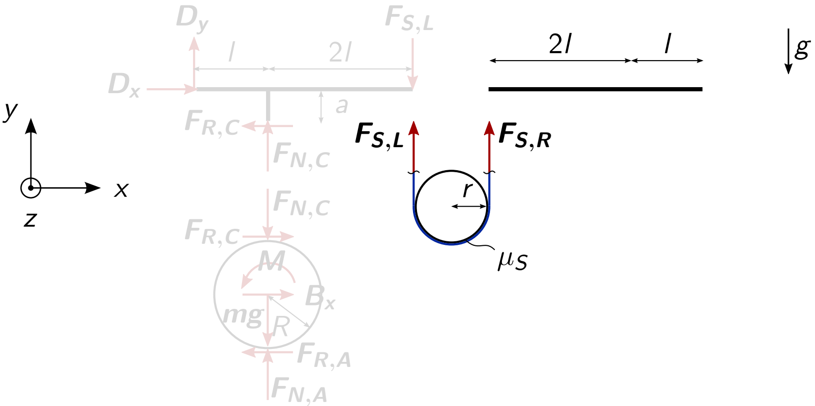
a) Freikörperbild

Gegeben: g ; m ; M ; R ; r ; l ; a ; μ_S ; μ_R



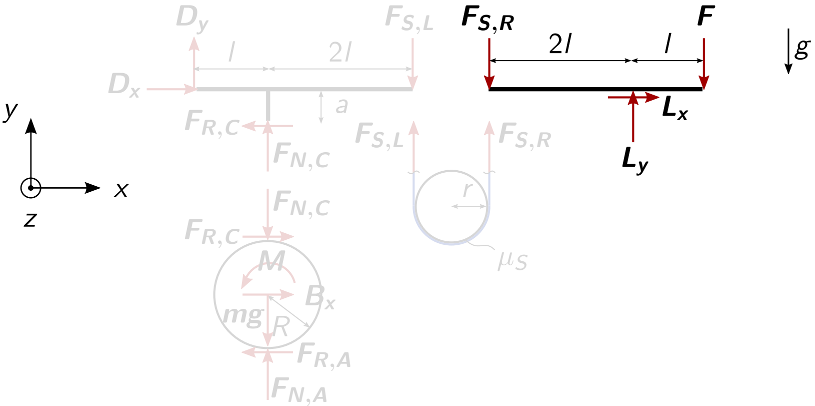
a) Freikörperbild

Gegeben: g ; m ; M ; R ; r ; l ; a ; μ_S ; μ_R



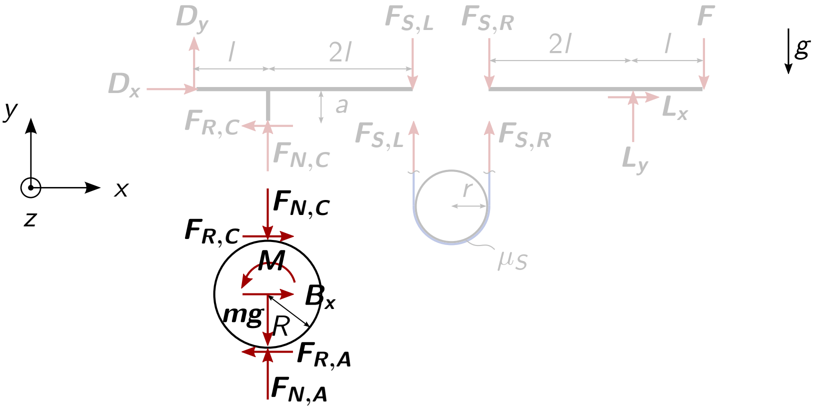
a) Freikörperbild

Gegeben: g ; m ; M ; R ; r ; l ; a ; μ_S ; μ_R



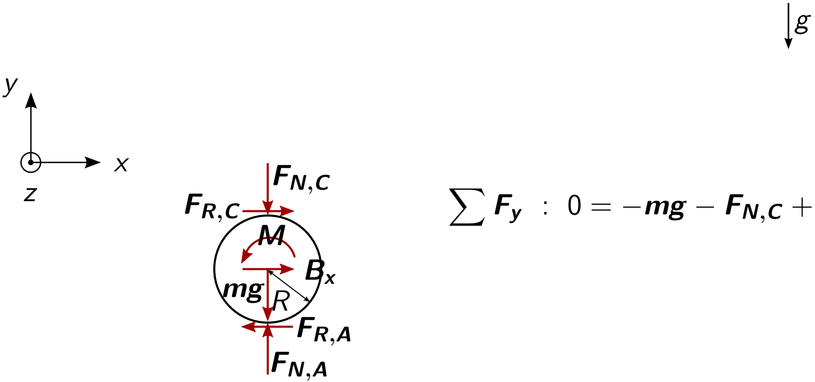
b) $\boldsymbol{F_{N,C}}$ bestimmen, damit das Rad ruht

Gegeben: g ; m ; M ; R ; r ; l ; a ; μ_S ; μ_R



b) $\boldsymbol{F_{N,C}}$ bestimmen, damit das Rad ruht

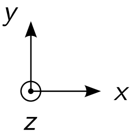
Gegeben: g ; m ; M ; R ; r ; l ; a ; μ_S ; μ_R

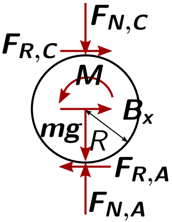


$$\sum \boldsymbol{F_y} \; : \; 0 = -\boldsymbol{mg} - \boldsymbol{F_{N,C}} + \boldsymbol{F_{N,A}}$$

b) $\boldsymbol{F_{N,C}}$ bestimmen, damit das Rad ruht

Gegeben: g ; m ; M ; R ; r ; l ; a ; μ_S ; μ_R



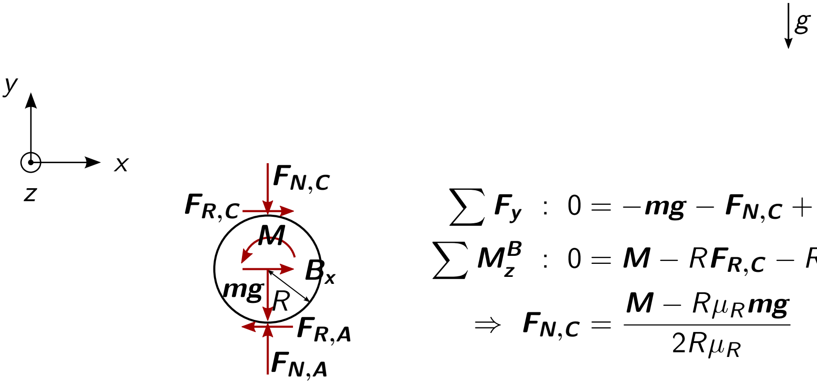


$$\sum F_y \; : \; 0 = -mg - F_{N,C} + F_{N,A}$$

$$\sum M_z^B \; : \; 0 = M - R F_{R,C} - R F_{R,A}$$

b) $\boldsymbol{F_{N,C}}$ bestimmen, damit das Rad ruht

Gegeben: g ; m ; M ; R ; r ; l ; a ; μ_S ; μ_R



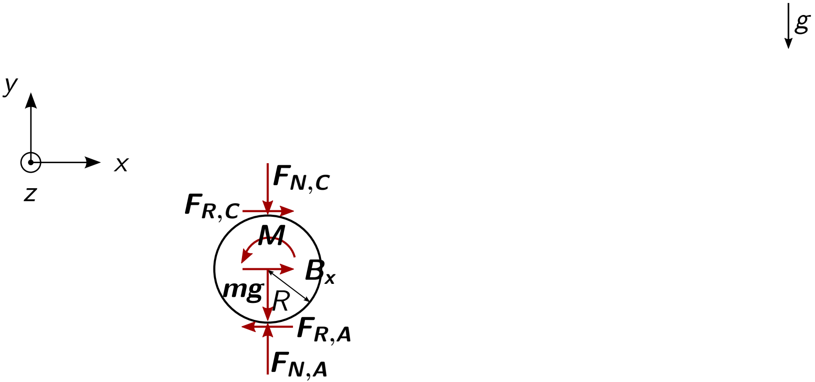
$$\sum F_y \; : \; 0 = -mg - F_{N,C} + F_{N,A}$$

$$\sum M_z^B \; : \; 0 = M - R F_{R,C} - R F_{R,A}$$

$$\Rightarrow \; F_{N,C} = \frac{M - R\mu_R mg}{2R\mu_R}$$

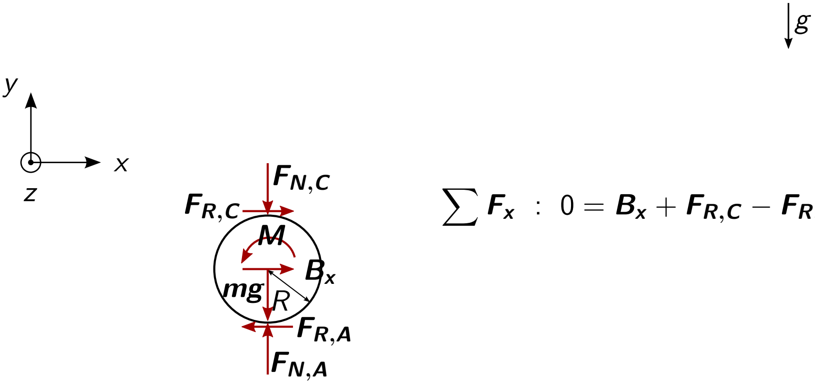
c) Lagerreaktionen in Punkt B bestimmen, $\boldsymbol{F_{N,C}}$ sei bekannt

Gegeben: g ; m ; M ; R ; r ; l ; a ; μ_S ; μ_R



c) Lagerreaktionen in Punkt B bestimmen, $\boldsymbol{F_{N,C}}$ sei bekannt

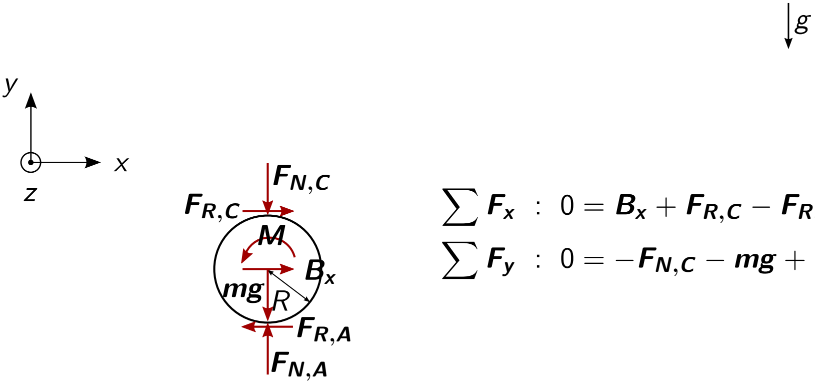
Gegeben: g ; m ; M ; R ; r ; l ; a ; μ_S ; μ_R



$$\sum F_x \; : \; 0 = B_x + F_{R,C} - F_{R,A}$$

c) Lagerreaktionen in Punkt B bestimmen, $\boldsymbol{F_{N,C}}$ sei bekannt

Gegeben: g ; m ; M ; R ; r ; l ; a ; μ_S ; μ_R

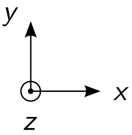


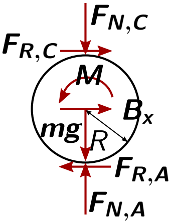
$$\sum F_x \ : \ 0 = B_x + F_{R,C} - F_{R,A}$$

$$\sum F_y \ : \ 0 = -F_{N,C} - mg + F_{N,A}$$

c) Lagerreaktionen in Punkt B bestimmen, $\boldsymbol{F_{N,C}}$ sei bekannt

Gegeben: g ; m ; M ; R ; r ; l ; a ; μ_S ; μ_R





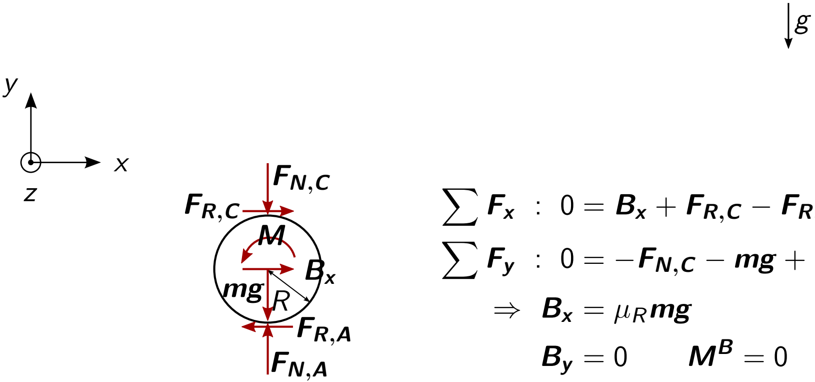
$$\sum \boldsymbol{F_x} \;:\; 0 = \boldsymbol{B_x} + \boldsymbol{F_{R,C}} - \boldsymbol{F_{R,A}}$$

$$\sum \boldsymbol{F_y} \;:\; 0 = -\boldsymbol{F_{N,C}} - \boldsymbol{mg} + \boldsymbol{F_{N,A}}$$

$$\Rightarrow \quad \boldsymbol{B_x} = \mu_R \boldsymbol{mg}$$

c) Lagerreaktionen in Punkt B bestimmen, $\boldsymbol{F_{N,C}}$ sei bekannt

Gegeben: g ; m ; M ; R ; r ; l ; a ; μ_S ; μ_R



$$\sum F_x \;:\; 0 = B_x + F_{R,C} - F_{R,A}$$

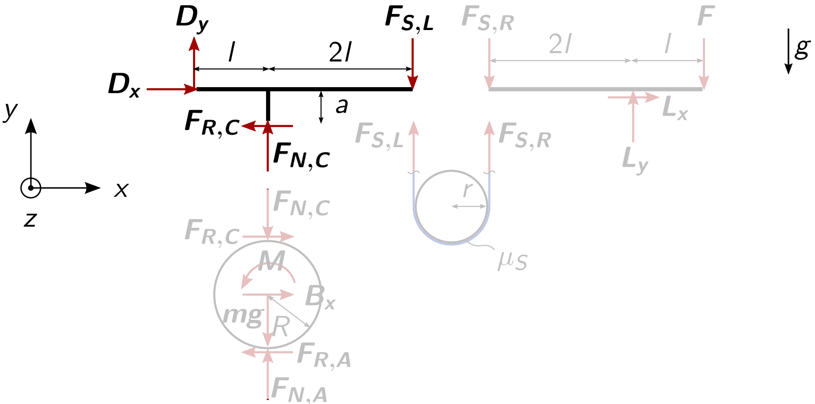
$$\sum F_y \;:\; 0 = -F_{N,C} - mg + F_{N,A}$$

$$\Rightarrow \quad B_x = \mu_R mg$$

$$B_y = 0 \qquad M^B = 0$$

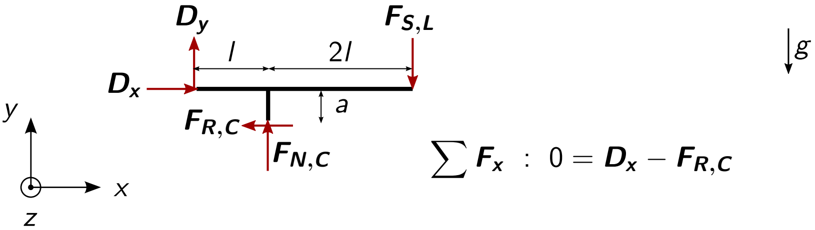
d) Lagerreaktionen in Punkt D und Seilkraft $\boldsymbol{F_{S,L}}$ bestimmen

Gegeben: g ; m ; M ; R ; r ; l ; a ; μ_S ; μ_R



d) Lagerreaktionen in Punkt D und Seilkraft $\boldsymbol{F_{S,L}}$ bestimmen

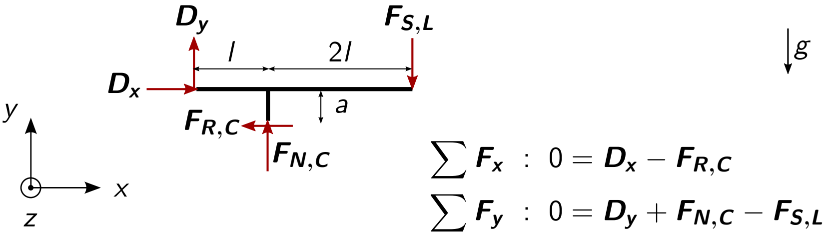
Gegeben: g ; m ; M ; R ; r ; l ; a ; μ_S ; μ_R



$$\sum \boldsymbol{F_x} \;:\; 0 = \boldsymbol{D_x} - \boldsymbol{F_{R,C}}$$

d) Lagerreaktionen in Punkt D und Seilkraft $\boldsymbol{F_{S,L}}$ bestimmen

Gegeben: g ; m ; M ; R ; r ; l ; a ; μ_S ; μ_R

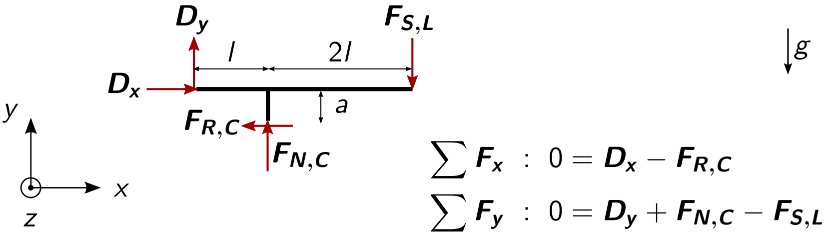


$$\sum F_x \ : \ 0 = D_x - F_{R,C}$$

$$\sum F_y \ : \ 0 = D_y + F_{N,C} - F_{S,L}$$

d) Lagerreaktionen in Punkt D und Seilkraft $\boldsymbol{F_{S,L}}$ bestimmen

Gegeben: g ; m ; M ; R ; r ; l ; a ; μ_S ; μ_R



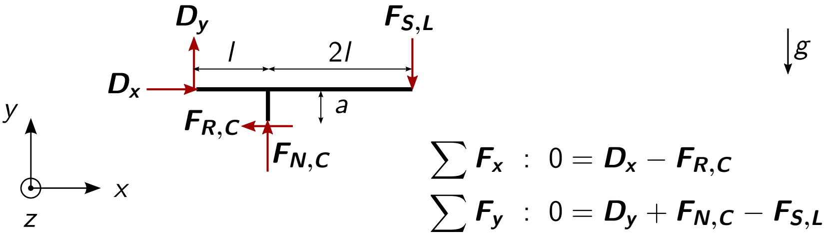
$$\sum F_x \ : \ 0 = D_x - F_{R,C}$$

$$\sum F_y \ : \ 0 = D_y + F_{N,C} - F_{S,L}$$

$$\sum M_z \ : \ 0 = -aF_{R,C} + lD_y - 2lF_{S,L}$$

d) Lagerreaktionen in Punkt D und Seilkraft $\boldsymbol{F_{S,L}}$ bestimmen

Gegeben: g ; m ; M ; R ; r ; l ; a ; μ_S ; μ_R



$$\sum \boldsymbol{F_x} \;:\; 0 = \boldsymbol{D_x} - \boldsymbol{F_{R,C}}$$

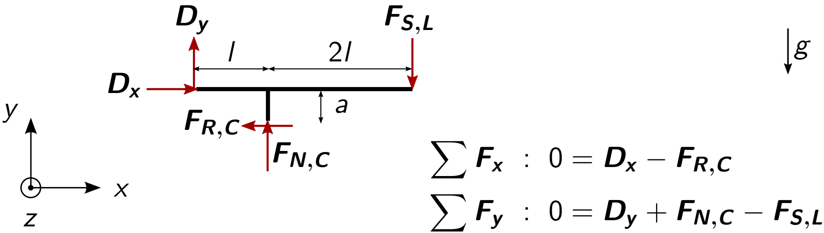
$$\sum \boldsymbol{F_y} \;:\; 0 = \boldsymbol{D_y} + \boldsymbol{F_{N,C}} - \boldsymbol{F_{S,L}}$$

$$\sum \boldsymbol{M_z} \;:\; 0 = -a\boldsymbol{F_{R,C}} + l\boldsymbol{D_y} - 2l\boldsymbol{F_{S,L}}$$

$$\boldsymbol{D_y} = \boldsymbol{F_{N,C}} \left(-\frac{a\mu_R}{3l} - \frac{2}{3} \right)$$

d) Lagerreaktionen in Punkt D und Seilkraft $\boldsymbol{F_{S,L}}$ bestimmen

Gegeben: g ; m ; M ; R ; r ; l ; a ; μ_S ; μ_R



$$\sum F_x \; : \; 0 = D_x - F_{R,C}$$

$$\sum F_y \; : \; 0 = D_y + F_{N,C} - F_{S,L}$$

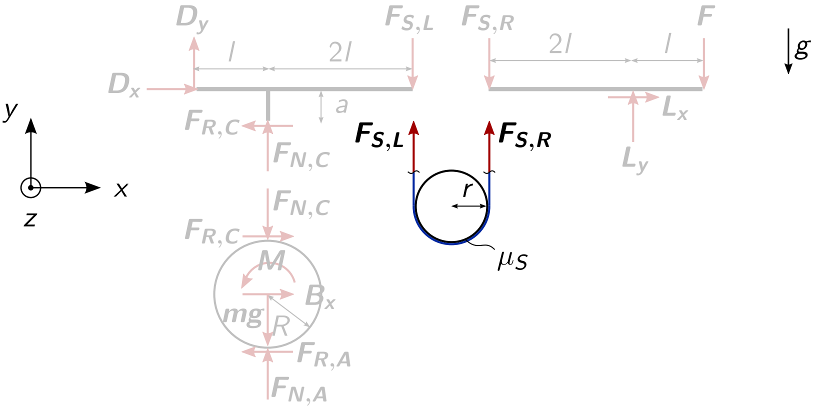
$$\sum M_z \; : \; 0 = -aF_{R,C} + lD_y - 2lF_{S,L}$$

$$D_y = F_{N,C}\left(-\frac{a\mu_R}{3l} - \frac{2}{3}\right)$$

$$F_{S,L} = \frac{F_{N,C}}{3}\left(1 - \frac{a\mu_r}{l}\right)$$

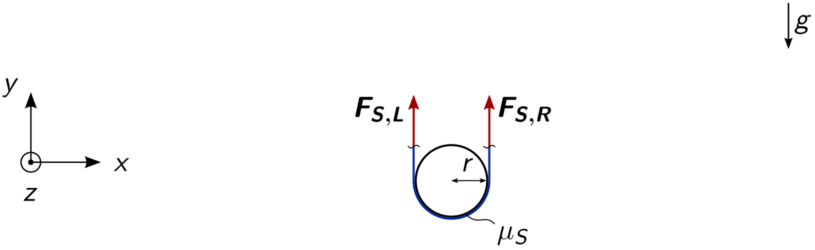
e) Seilkraft $\boldsymbol{F_{S,R}}$ bestimmen, um das Rad zu halten

Gegeben: g ; m ; M ; R ; r ; l ; a ; μ_S ; μ_R



e) Seilkraft $\boldsymbol{F_{S,R}}$ bestimmen, um das Rad zu halten

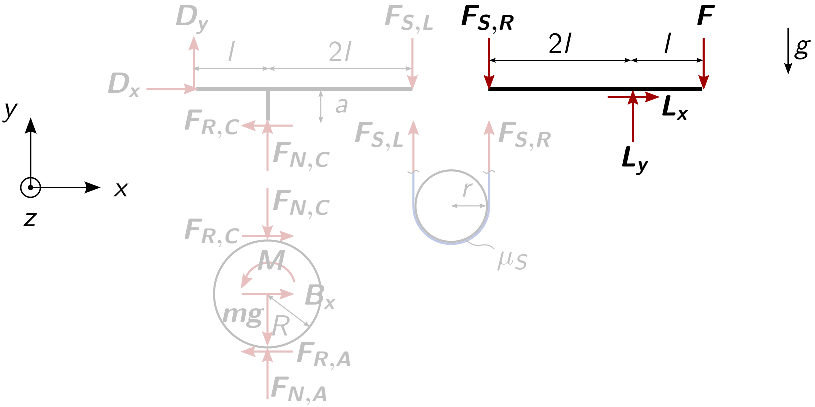
Gegeben: g ; m ; M ; R ; r ; l ; a ; μ_S ; μ_R



$$\boldsymbol{F_{S,R}} = \boldsymbol{F_{S,L}} e^{\pi \mu_S}$$

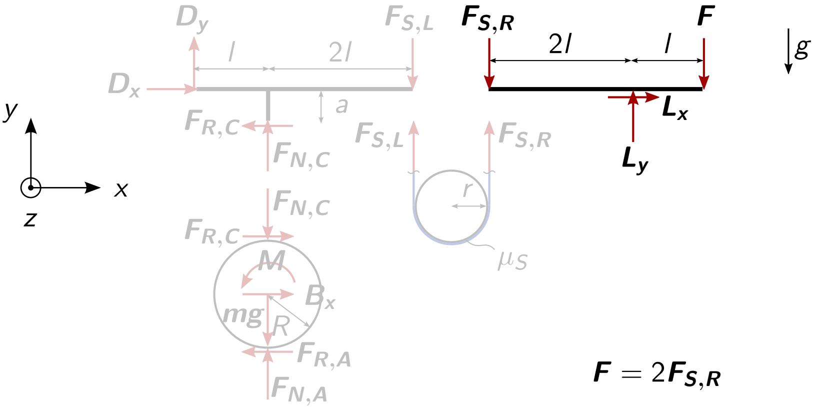
f) Betrag von $\boldsymbol{F}$ bestimmen, um das Rad zu halten

Gegeben: g ; m ; M ; R ; r ; l ; a ; μ_S ; μ_R



f) Betrag von $\boldsymbol{F}$ bestimmen, um das Rad zu halten

Gegeben: g ; m ; M ; R ; r ; l ; a ; μ_S ; μ_R



$$\boldsymbol{F} = 2\boldsymbol{F_{S,R}}$$

Fragen?