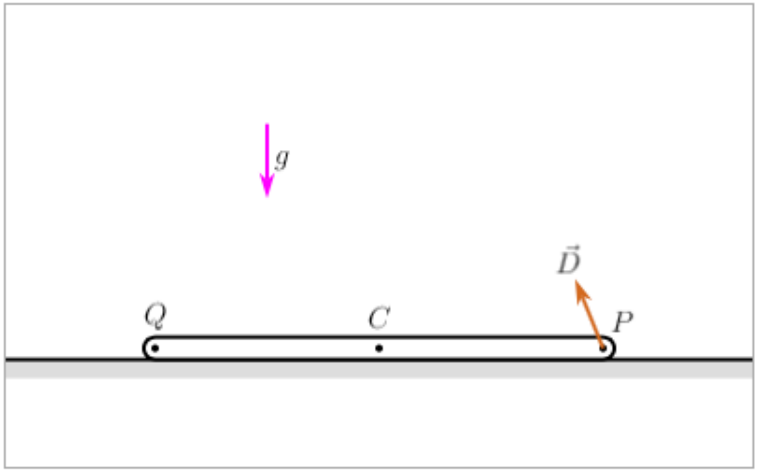
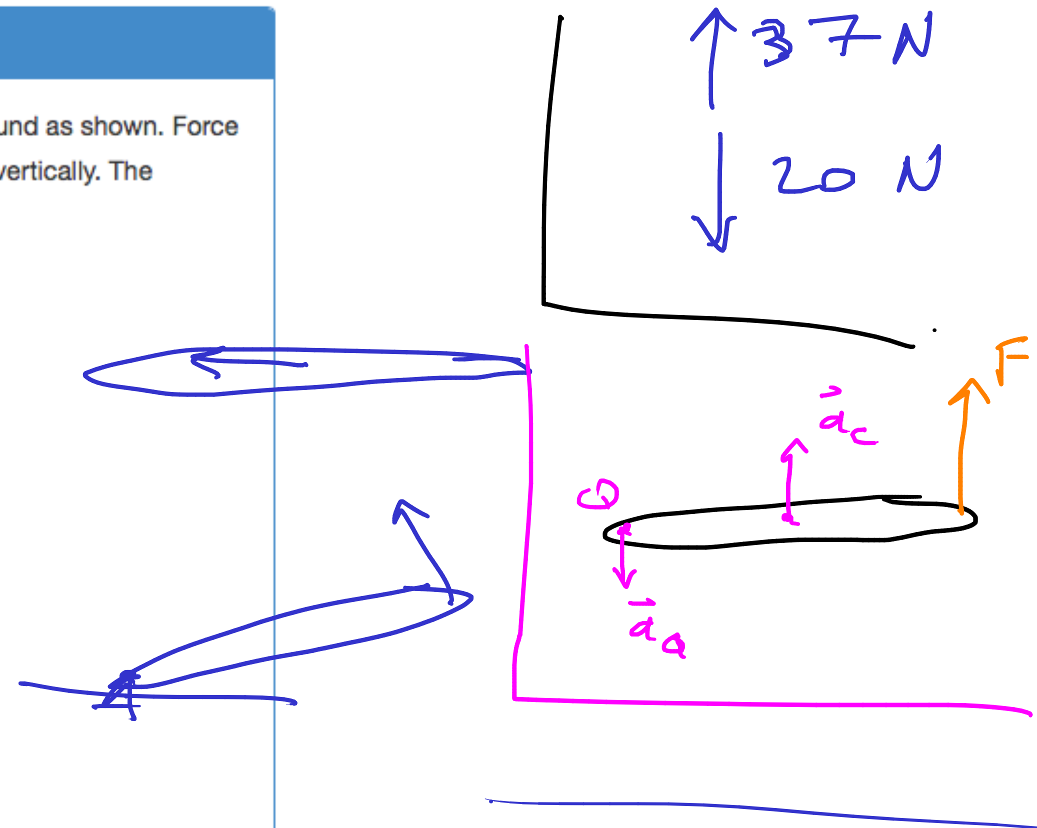
#9-17. Rod lifting kinetics (rodLiftKinetics)

A uniform rigid rod of mass $m = 2\ \mathrm{kg}$ and length $\ell = 8\ \mathrm{m}$ starts at rest on a flat ground as shown. Force $\vec{D} = -15\hat{\imath} + 37\hat{\jmath}\ \mathrm{N}$ acts at point P on the right end, and gravity $g = 9.8\ \mathrm{m/s^2}$ acts vertically. The coefficient of friction between the rod and the ground is $\mu = 0.5$.



What is the acceleration $\vec{a}_C$ of point C?

$\vec{a}_C =$ ______ $\hat{\imath}$ + ______ $\hat{\jmath}$ $\mathrm{m/s^2}$

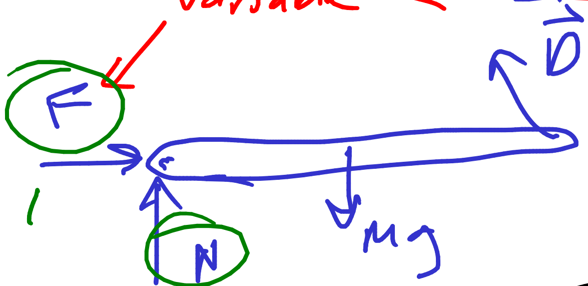


3 cases: Q sticks, Q slips left, Q slips right

seems unlikely

variable

doesn't matter which way we choose as +ve

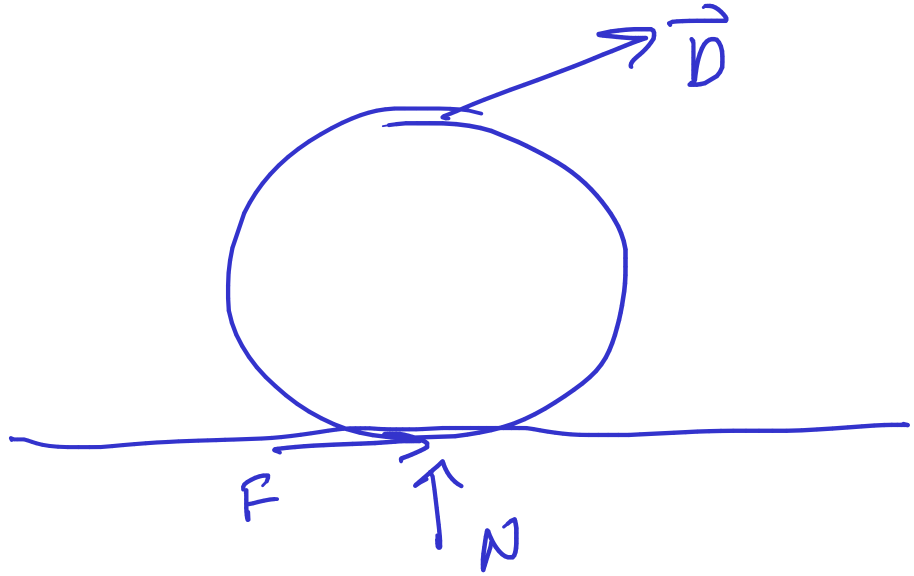


$$2\quad \Sigma \vec{F} = m\vec{a}_c \quad 2$$

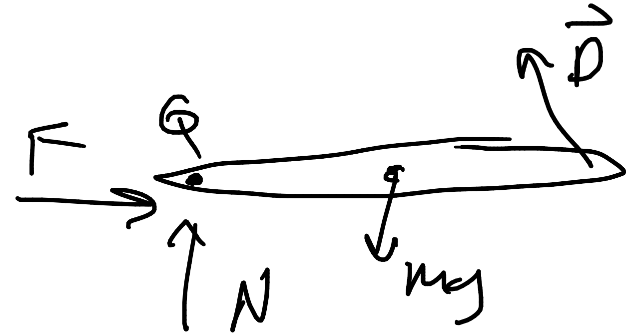
$$1\quad \Sigma M_{Cz} = I_c \alpha_z \quad 1$$

$$\vec{a}_Q = 0 \overset{2}{=} \vec{a}_c + \vec{\alpha} \times \vec{r}_{cQ}$$

$\Rightarrow$ check: $|F| \le \mu |N|$



Slipping left



$\cancel{N = mg - D_y}$ dyn!

2 $\sum \vec{F} = m\vec{a}_c$ 2

1 $\sum M_{cz} = I_c \alpha_z$ 1

1 $F = \mu N$ 1

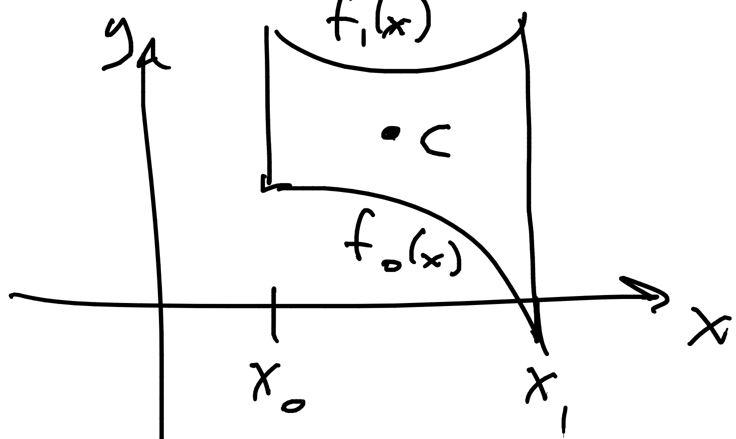
1

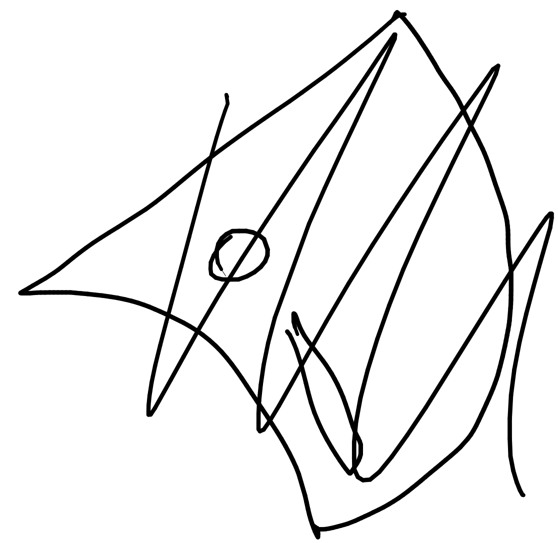
1 $a_{Qy} = 0$

Check: F opposes motion

$\xrightarrow{F}$ $\quad \xleftarrow{\vec{a}_Q}$

$\left\{ \begin{array}{l} \text{friction force at contact.} \\ \text{acc. at contact.} \end{array} \right.$





$$\vec{r}_c = \frac{1}{m}\iint_{B} \rho\, \vec{r}\, dA$$

$$m = \iint_{B} \rho\, dA = \rho \int_{x_0}^{x_1}\int_{f_0(x)}^{f_1(x)} 1 \; dy\, dx$$

$$\vec{r}_c = \frac{1}{m}\iint \rho\,(x\hat{i} + y\hat{j})\, dy\, dx$$

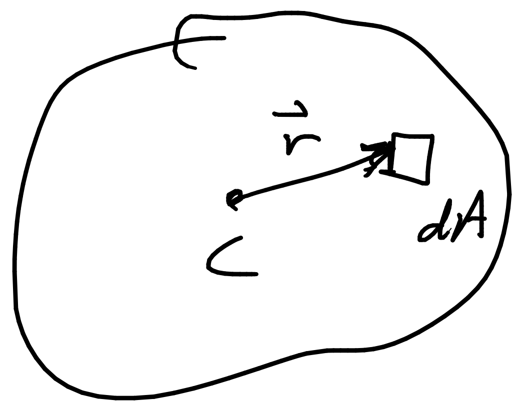
$$\int (3\hat{i} + 2x\hat{j})\,dx = \int 3\hat{i}\,dx + \int 2x\hat{j}\,dx$$

$$= \hat{i}\underbrace{\int 3\,dx} + \hat{j}\underbrace{\int 2x\,dx}$$

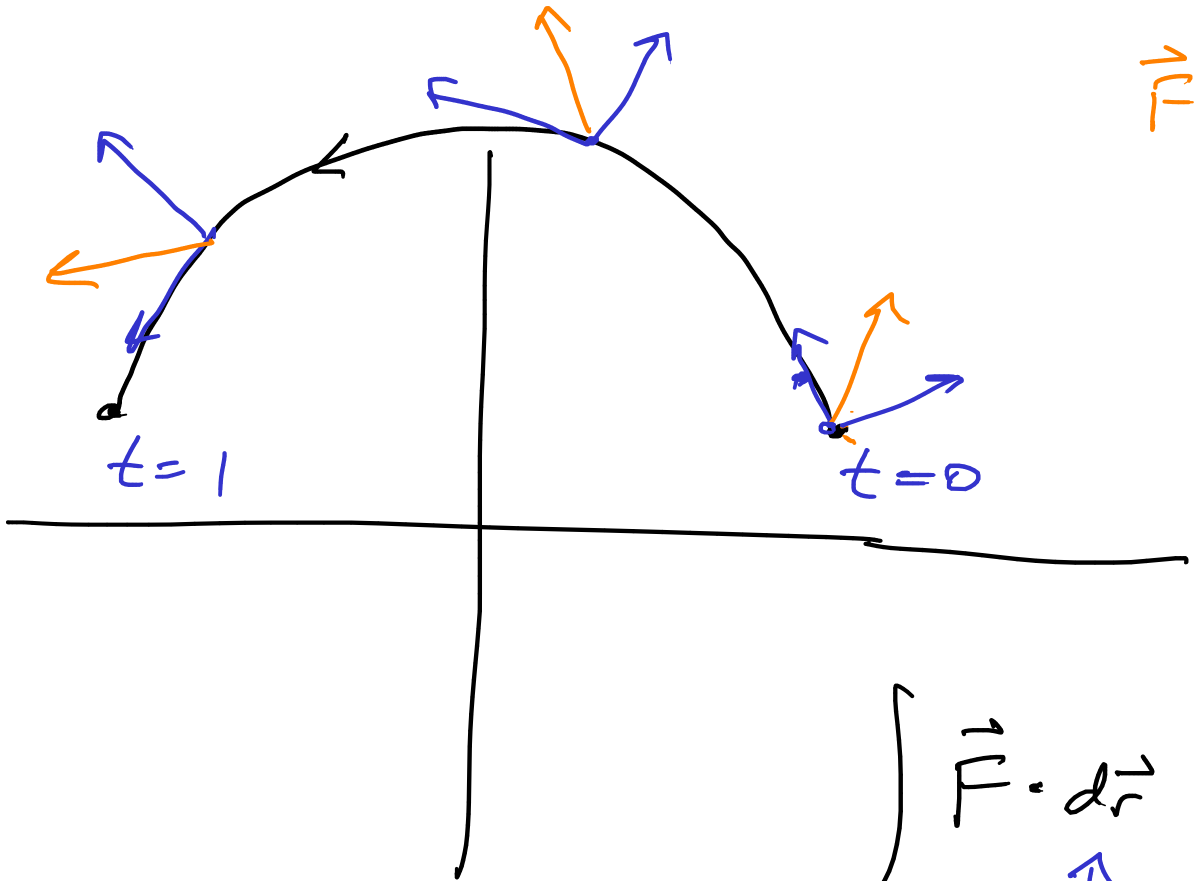
$$= \left(\int 3\,dx\right)\hat{i} + \left(\int 2x\,dx\right)\hat{j}$$

$$I_C = \iint \rho\, r_{cp}^2\, dA$$

$$= \iint \rho\left((x-x_c)^2 + (y-y_c)^2\right) dy\,dx$$



$$\|(x\hat{i}+y\hat{j}) - (x_c\hat{i} + y_c\hat{j})\|^2$$



$\vec{F} = \hat{e}_r + \hat{e}_\theta$

$$\int \vec{F} \cdot d\vec{r} = \int \vec{F} \cdot \vec{v}\, dt$$

$r\hat{e}_\theta$

$\vec{r}(t) =$ ___ $\hat{\imath}$ + ___ $\hat{\jmath}$