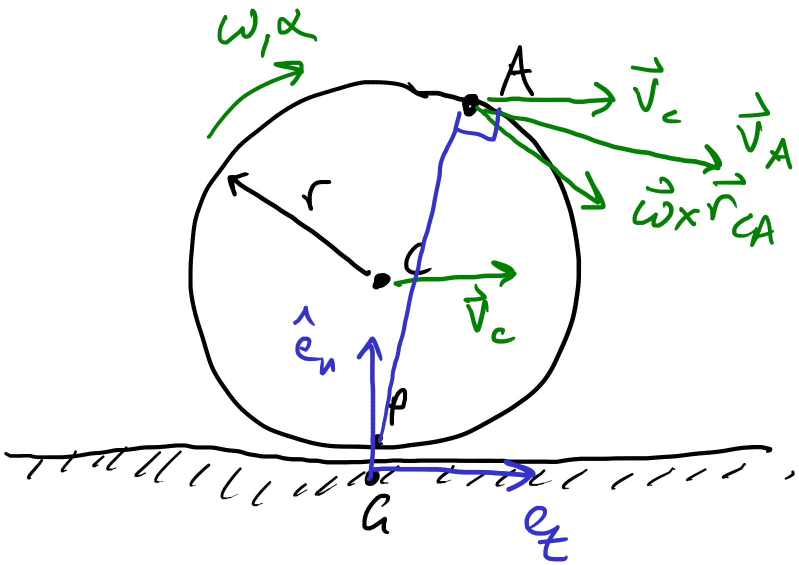
Rolling (no slipping)



$\vec{\omega} = -\omega\,\hat{e}_b$

$\vec{\alpha} = -\alpha\,\hat{e}_b$

A: +

B: −

$\hat{e}_b = \hat{e}_t \times \hat{e}_n$ ←

~~$\hat{e}_b = \hat{e}_n \times \hat{e}_t$~~

T / N / B

$\hat{\imath}$ $\hat{\jmath}$ $\hat{k}$

r θ z

velocity

$$\boxed{\vec{v}_c = r\omega\,\hat{e}_t} \quad \text{for all } t$$

$\vec{v}_P = 0$ at an instant

$\vec{v}_A = \vec{v}_c + \vec{\omega}\times\vec{r}_{cA}$

$= \vec{\omega}\times\vec{r}_{PA}$

$$\boxed{v_c = r\omega}$$

acceleration

$\vec{v}_c = r\omega\,\hat{e}_t$

$\vec{a}_c = \dot{\vec{v}}_c = r\dot{\omega}\,\hat{e}_t + r\omega\,\dot{\hat{e}}_t$

0

$$\boxed{\vec{a}_c = r\alpha\,\hat{e}_t}$$

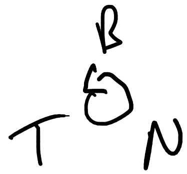
$$\boxed{a_c = r\alpha}$$

$$\vec{a}_p = \vec{a}_c + \vec{\alpha} \times \vec{r}_{cp} + \vec{\omega} \times (\vec{\omega} \times \vec{r}_{cp})$$

$$= r\alpha\,\hat{e}_t + (-\alpha\,\hat{e}_b) \times (-r\hat{e}_n) - \omega^2(-r\hat{e}_n)$$

TNB

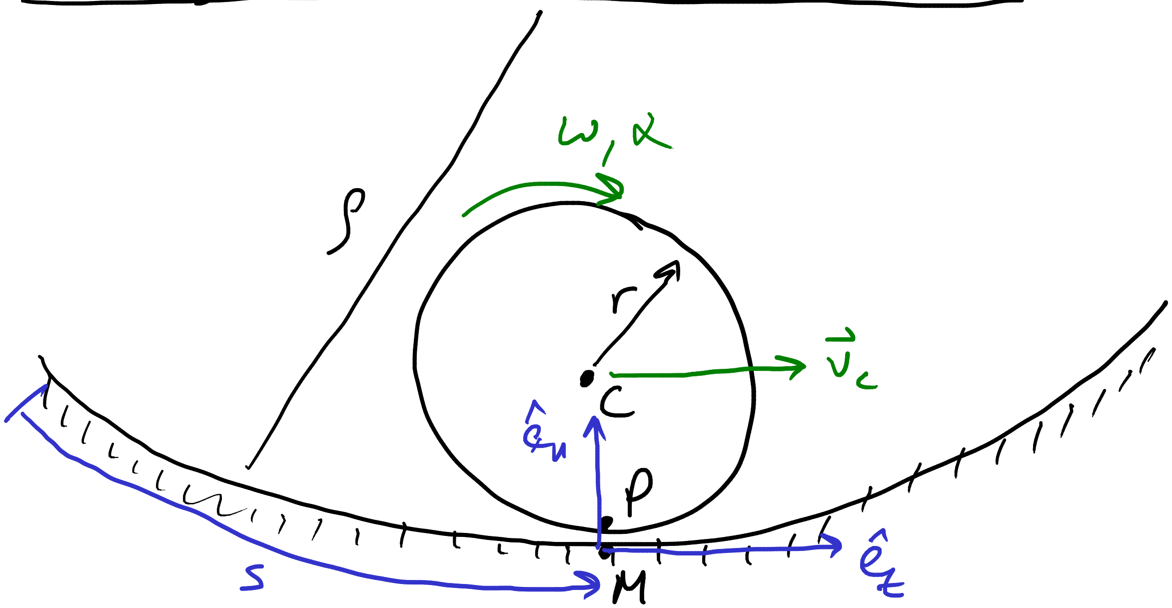
$$= r\cancel{\alpha\,\hat{e}_t} + r\alpha\cancel{(-\hat{e}_t)} + r\omega^2\hat{e}_n$$



$$= r\omega^2\hat{e}_n$$

$$\vec{a}_A = \vec{a}_c + \vec{\alpha} \times \vec{r}_{cA} - \omega^2\vec{r}_{cA}$$

Rolling on curved surfaces



ρ = radius of curvature of ground.

different to textbook!

M = inst. center of rotation

P = point attached to body that is momentarily at M

Note: $\vec{v}_M \neq \vec{v}_P$

M must move along ground

$\vec{v}_M = \dot{s}\,\hat{e}_t$ $\qquad$ $\vec{\omega} = -\omega\,\hat{e}_b$

$\vec{v}_P = 0$ $\qquad$ $\vec{\alpha} = -\alpha\,\hat{e}_b$