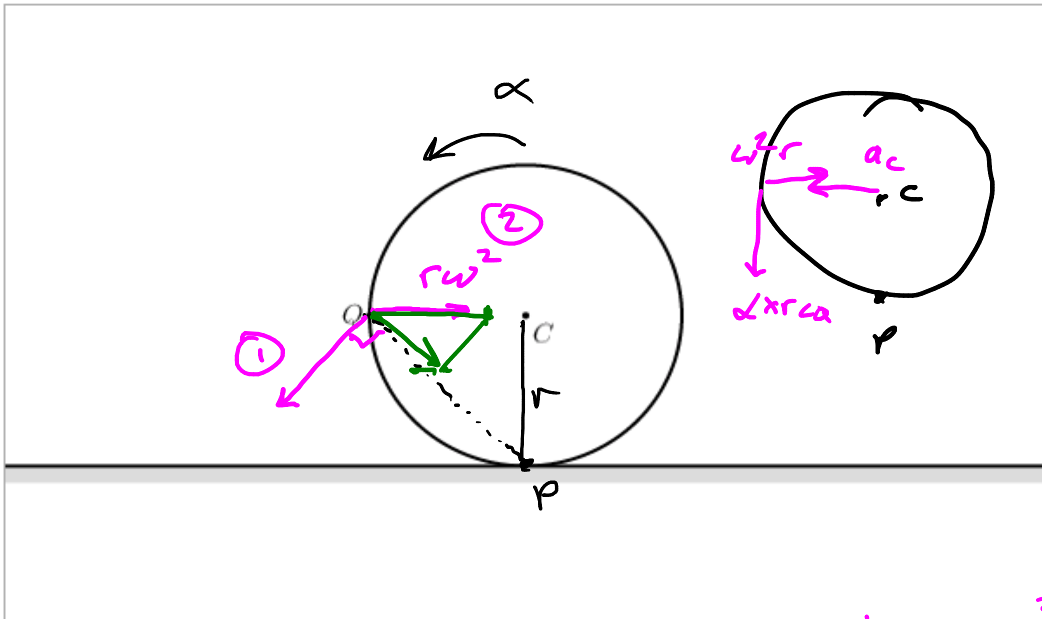
Exam review – no iclicker points.

Acceleration of rolling bodies – no slip.

#7-18. Acceleration of a point on a body rolling horizontally, graphical

A circular rigid body is rolling without slipping on a fixed flat surface in 2D as shown below. Point Q is fixed to the body and the angular acceleration $\vec{\alpha} = \alpha\hat{k}$ and angular velocity $\vec{\omega} = \omega\hat{k}$ of the body satisfy $3\alpha = \omega^2$.



Draw the acceleration direction $\hat{a}_Q$ of point Q.

$\alpha = \frac{1}{3}\omega^2$

positive

CCW ang acc

just for rolling on flat surfaces

$\vec{a}_C = \vec{\alpha} \times \vec{r}_{PC}$ $\xleftarrow{\alpha r}$

$\vec{a}_Q = \vec{a}_C + \vec{\alpha} \times \vec{r}_{CQ} - \omega^2 \vec{r}_{CQ}$

$= \vec{\alpha} \times \vec{r}_{PQ} - \omega^2 \vec{r}_{CQ}$ ① ②

$\alpha \frac{3}{2} r$ $\quad r\omega^2$

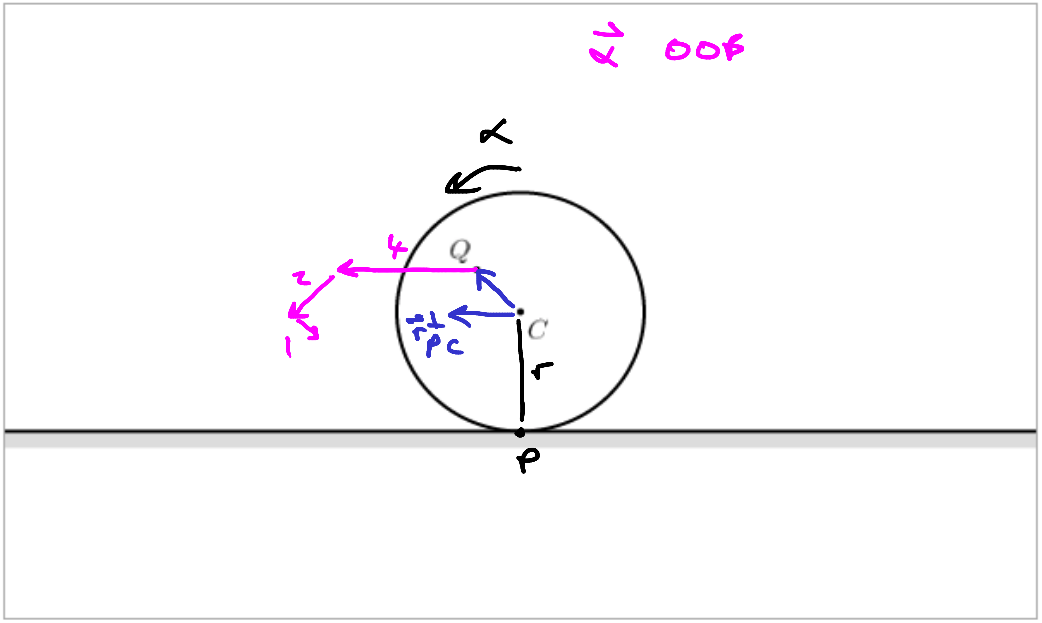
$= \frac{1}{2} r\omega^2$

$\downarrow \alpha r$ $\quad \xrightarrow{\omega^2 r}$

$\xleftarrow{\alpha r} + \downarrow \alpha r + \xrightarrow{3\alpha r} = \xrightarrow{2\alpha r} \downarrow \alpha r$

#7-18. Acceleration of a point on a body rolling horizontally, graphical

A circular rigid body is rolling without slipping on a fixed flat surface in 2D as shown below. Point Q is fixed to the body and the angular acceleration $\vec{\alpha} = \alpha\hat{k}$ and angular velocity $\vec{\omega} = \omega\hat{k}$ of the body satisfy $\alpha = 2\omega^2$.



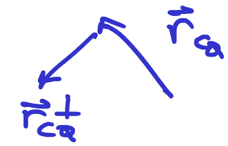
Draw the acceleration direction $\hat{a}_Q$ of point Q.

$$\vec{a}_Q = \underbrace{\vec{\alpha} \times \vec{r}_{PC}}_{\alpha \vec{r}_{PC}^{\perp}} + \underbrace{\vec{\alpha} \times \vec{r}_{CQ}}_{\alpha \vec{r}_{CQ}^{\perp}} - \omega^2 \vec{r}_{CQ}$$

$\alpha r \qquad \frac{1}{2}\alpha r \qquad \frac{1}{2}\omega^2 r$

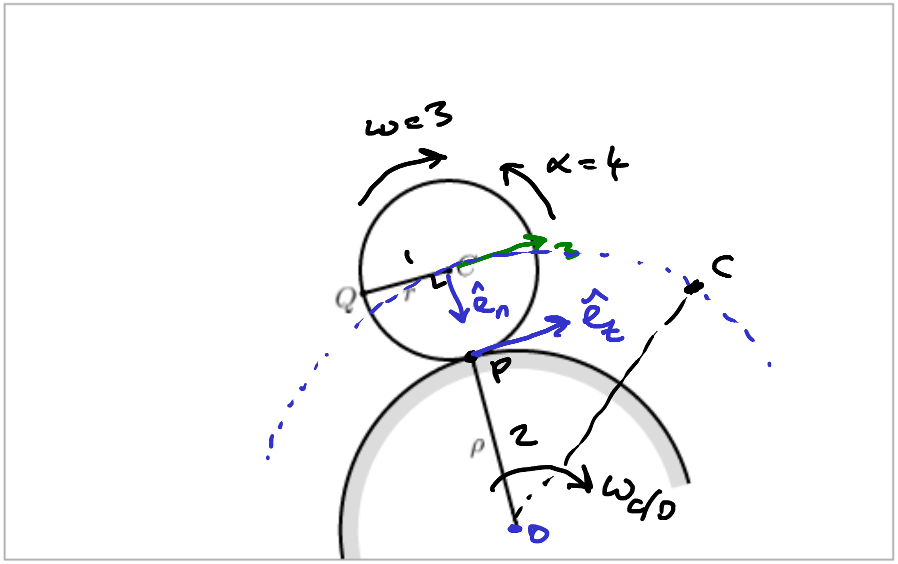
$2\omega^2 r \qquad \omega^2 r \qquad \frac{1}{2}\omega^2 r$

$4 \qquad 2 \qquad 1$

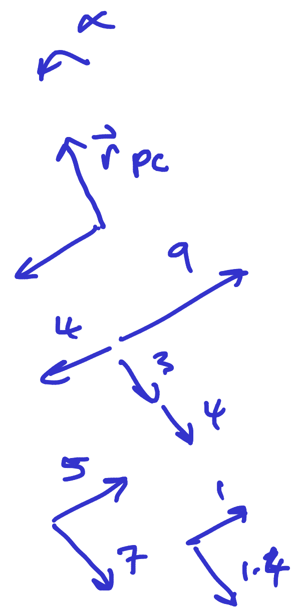


#7-26. Acceleration direction of rolling on a curved surface

A circular rigid body is rolling without slipping on a curved surface in 2D, as shown. At the current instant the body has a clockwise angular velocity of 3 rad/s and a counterclockwise angular acceleration of $4\ \mathrm{rad/s^2}$. The circular rigid body has radius $r = 1$ m and the curved surface has radius of curvature $\rho = 2$ m. Point Q is fixed to the edge of the body.



Draw the direction of the acceleration of point Q on the figure.



$\vec{V}_c = \vec{\omega} \times \vec{r}_{PC} = \omega r \hat{e}_t = 3\, e_t$

$\vec{a}_c = \vec{\alpha} \times \vec{r}_{PC} + \frac{v_c^2}{R}\hat{e}_n$

$R = \rho + r = 3$

$\cancel{\omega^2 R}$?

$\omega_{c/o}$

$\vec{a}_c = -\alpha r \hat{e}_t + \frac{v_c^2}{R}\hat{e}_n$

inconsistent ω, α dir

$\vec{a}_c = \vec{\alpha} \times \vec{r}_{PC} + \frac{v_c^2}{R}\hat{e}_n$

4 3

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

4 9