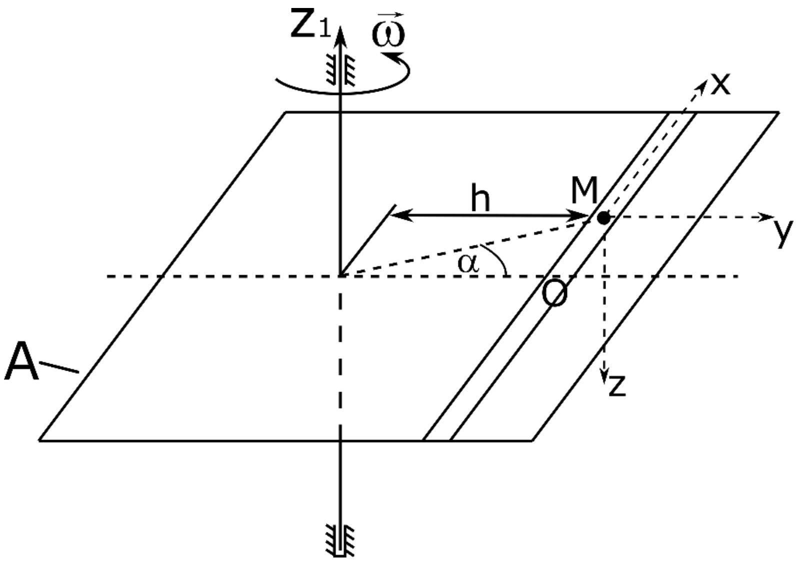
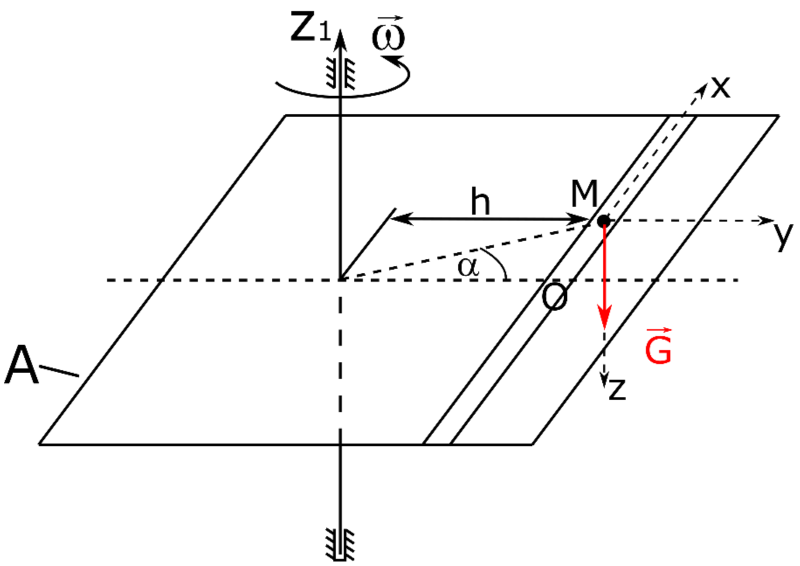
Dynamics of complex motion

Example. The ball considered as a material point moves inside the cylindrical channel of body A, which is also in motion. Find the equation for the relative motion of this ball x (t), taking the point O as its starting point. Also calculate the x coordinate and pressure of the ball on the channel wall when time t is given. Dane: $m = 0{,}02kg$, $\omega = \pi\ s^{-1}$, $x_o = 0\ m$, $\dot{x}_o = 0{,}2\ m/s$, $t = 0{,}4\ s$, $h = 0{,}15\ m$.

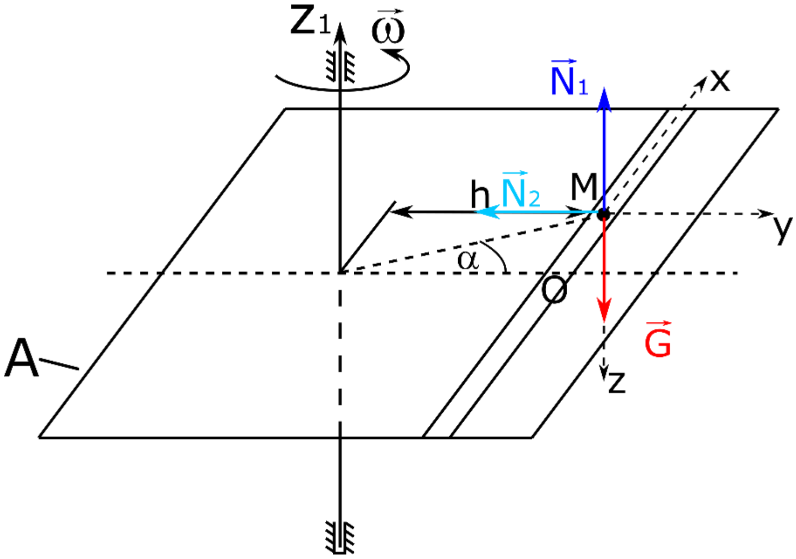


$$m\vec{a}_r = \vec{F} + \vec{R} + \vec{D}$$

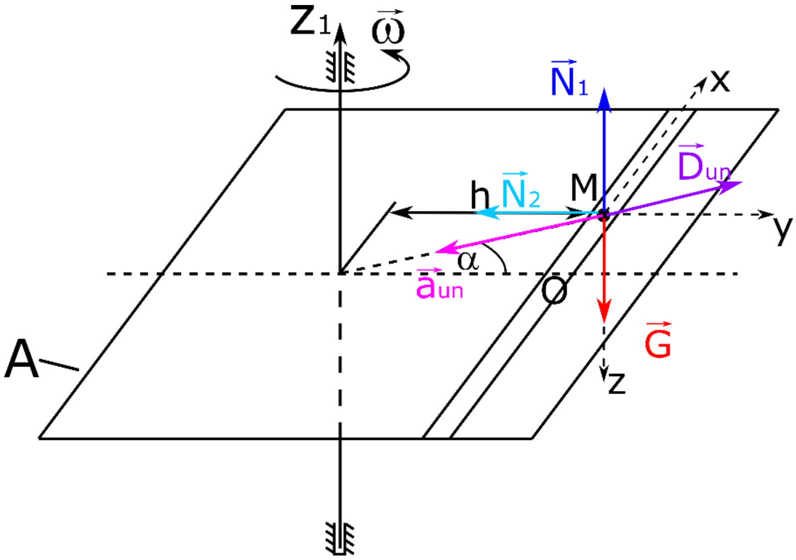
External forces acting on the point $\vec{F} = \vec{G}$



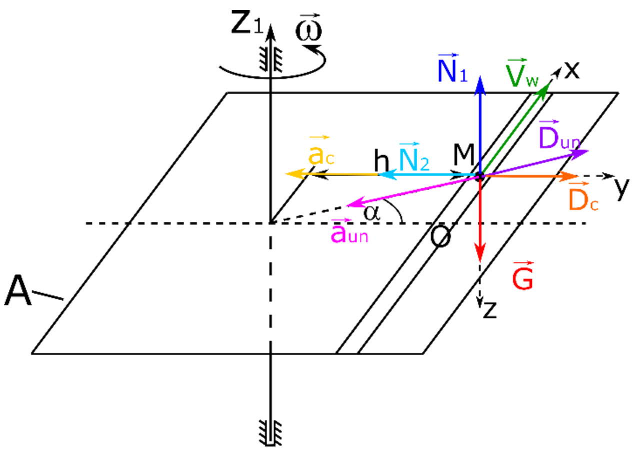
Reaction forces acting on the point $\vec{R} = \vec{N}_1 + \vec{N}_2$

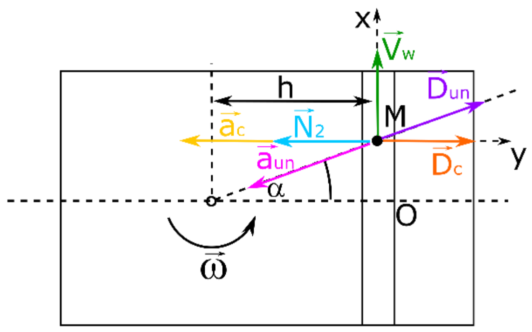


Inertia forces acting on point $\vec{D}$, are related to accelerations. $\vec{D}_{un}$ force related to the normal lifting acceleration. Since $\omega = const$ there is no tangent component of rising acceleration.



$\vec{D}_C$ force associated with Coriolis acceleration. Below are all the forces acting on a material point.





$$D_{un} = m\omega^2 r$$

$$D_C = 2m\omega * V_w * \sin(\vec{\omega}, \overrightarrow{V_w})$$

Since the vectors $\vec{\omega}\ i\ \overrightarrow{V_w}$ are perpendicular to each other, the sine of the angle between them is 1. In addition, we do not know the relative velocity of the material point, but we know that this point moves along the OX axis, therefore its speed will be a derivative of the distance after x, so we can write.

$$D_C = 2m\omega * \dot{x}$$

$$\frac{OM}{r} = \sin\alpha \Rightarrow \frac{x}{r} = \sin\alpha$$

$$m\ddot{x} = D_{un}\sin\alpha$$

$$m\ddot{x} = m\omega^2 r\sin\alpha \ \backslash m$$

$$\ddot{x} = \omega^2 r\sin\alpha$$

$$\ddot{x} = \omega^2 r\frac{x}{r}$$

$$\ddot{x} = \omega^2 x$$

$$\ddot{x} - \omega^2 x = 0$$

$$x = e^{rt};\ \dot{x} = re^{rt};\ \ddot{x} = r^2 e^{rt}$$

$$r^2 e^{rt} - \omega^2 e^{rt} = 0 \backslash e^{rt}$$

$$r^2 - \omega^2 = 0$$

$$(r - \omega)(r + \omega) = 0$$

$$r_1 = \omega;\ r_2 = -\omega$$

$$x = C_1 e^{r_1 t} + C_2 e^{r_2 t}$$

$$x = C_1 e^{\omega t} + C_2 e^{-\omega t}$$

$$x = C_1 e^{\pi t} + C_2 e^{-\pi t}$$

$$\dot{x} = \pi C_1 e^{\pi t} - \pi C_2 e^{-\pi t}$$

$$x(0) = 0 \Rightarrow C_1 + C_2 = 0 \Rightarrow C_1 = -C_2$$

$$\dot{x}(0) = 0{,}2 \Rightarrow \pi C_1 - \pi C_2 = 0{,}2 \Rightarrow -2\pi C_2 = 0{,}2$$

$$C_1 = 0{,}03$$

$$C_2 = -0{,}03$$

$$x = 0{,}03e^{\pi t} - 0{,}03e^{-\pi t}$$

$$x(t) = 0{,}097m$$

$$\dot{x} = 0{,}094C_1 e^{\pi t} + 0{,}094C_2 e^{-\pi t}$$

$$\dot{x}(t) = 0{,}357\ m/s$$

Determination of the pressure of the ball on the walls of the tube

$$m\ddot{y} = -N_2 + D_C + D_{un}\cos\alpha$$

$$\ddot{y} = 0$$

$$0 = -N_2 + D_C + D_{un}\cos\alpha$$

$$N_2 = D_C + D_{un}\cos\alpha$$

$$N_2 = 2m\omega * \dot{x} + m\omega^2 r\frac{h}{r}$$

$$N_2 = 2m\omega * \dot{x} + m\omega^2 h$$

$$N_2 = 0{,}074$$

$$m\ddot{z} = -N_1 + G$$

$$\ddot{z} = 0$$

$$0 = -N_1 + G$$

$$N_1 = G = 0{,}1962$$

$$N = \sqrt{{N_1}^2 + {N_2}^2} = 0{,}21N$$

The pressure of the ball against the wall is equal to the value of N, but it is opposite.