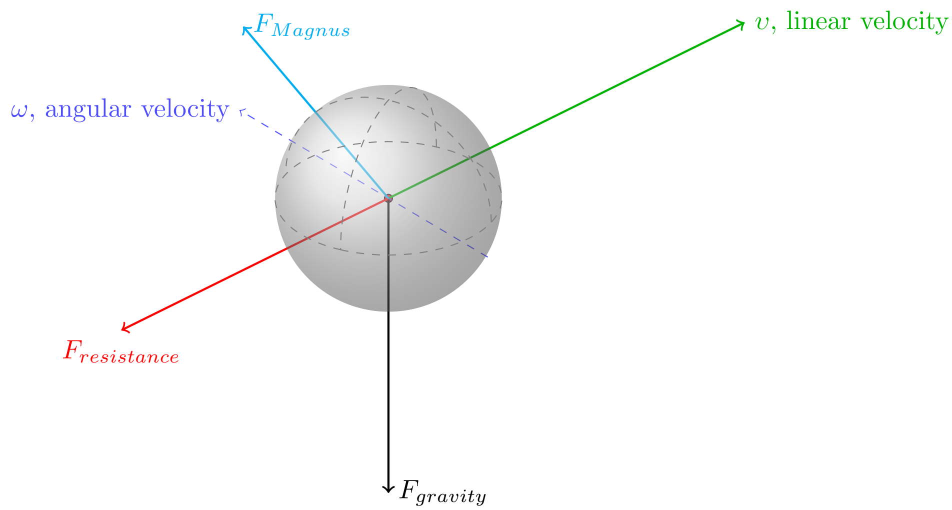
Ball's aerodynamycs



Main forses

$F_{gravity} = mg$
$F_{resistance} = \alpha \upsilon^2$ *– a force acting opposite to the relative motion of a moving ball.*
$F_{Magnus} = \beta \left[\vec{\omega} \times \vec{v}\right]$ *– a force arising from the pressure difference on the walls of the ball.*

Dynamics of the system

Newton's laws of motion:

$$m \begin{bmatrix} \ddot{x} \\ \ddot{y} \\ \ddot{z} \end{bmatrix} = -\alpha \begin{bmatrix} \dot{x}^2 \\ \dot{y}^2 \\ \dot{z}^2 \end{bmatrix} - \beta \left[\vec{\omega} \times \vec{v}\right] - m \begin{bmatrix} 0 \\ 0 \\ g \end{bmatrix}$$

$$\left[\vec{\omega} \times \vec{v}\right] = \det \begin{bmatrix} \vec{i} & \vec{j} & \vec{k} \\ \omega_x & \omega_y & \omega_z \\ \dot{x} & \dot{y} & \dot{z} \end{bmatrix} = \begin{bmatrix} 0 \cdot \dot{x} - \omega_z \dot{y} + \omega_y \dot{z} \\ \omega_z \dot{x} + 0 \cdot \dot{y} - \omega_x \dot{z} \\ -\omega_y \dot{x} + \omega_x \dot{y} + 0 \cdot \dot{z} \end{bmatrix}$$

$$m \begin{bmatrix} \ddot{x} \\ \ddot{y} \\ \ddot{z} \end{bmatrix} = - \begin{bmatrix} \alpha \dot{x}^2 - \beta \omega_z \dot{y} + \beta \omega_y \dot{z} \\ \beta \omega_z \dot{x} + \alpha \dot{y}^2 - \beta \omega_x \dot{z} \\ -\beta \omega_y \dot{x} + \beta \omega_x \dot{y} + \alpha \dot{z}^2 \end{bmatrix} - m \begin{bmatrix} 0 \\ 0 \\ g \end{bmatrix}$$