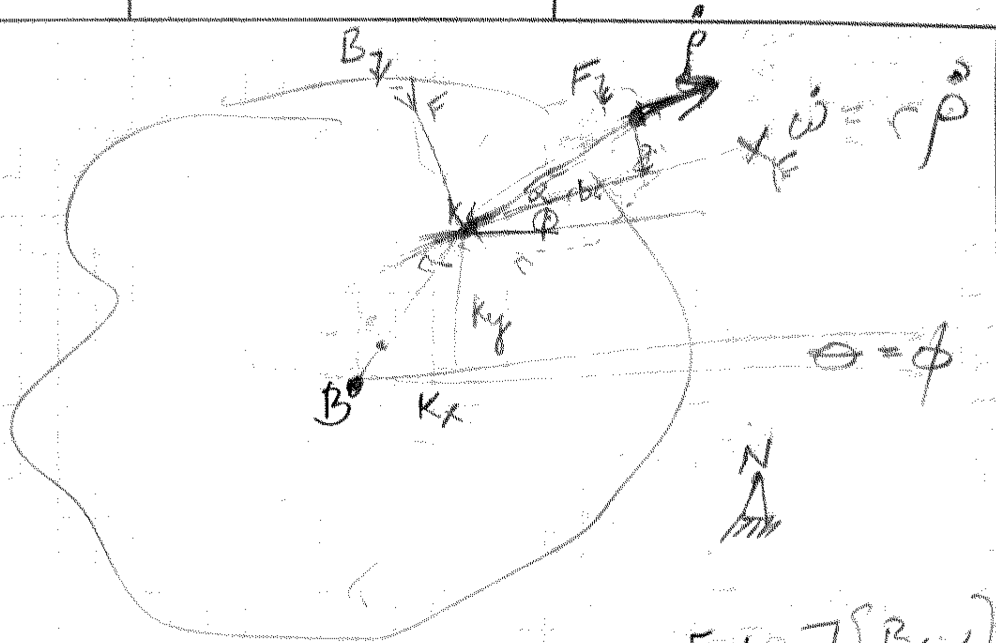
$\omega_B^N = \dot{\theta}$

$\omega_F^B = \dot{\phi}$

$\omega_F^N = \omega_B^N + \omega_F^B$

$\omega_F^N = \dot{\theta} + \dot{\phi}$



$${}^F x_C^K = \begin{bmatrix} -b \\ -a \\ 0 \end{bmatrix} = \begin{Bmatrix} -Bc\alpha \\ -Bs\alpha \\ 0 \end{Bmatrix}$$

$$\dot{x}_K = \dot{x}_C + \omega_F^N \otimes {}^N x_C^K$$

$$\dot{x}_K = \begin{bmatrix} -rc\phi\dot{\rho} \\ -rs\phi\dot{\rho} \\ 0 \end{bmatrix} + \begin{bmatrix} (\dot{\theta}+\dot{\phi})(bs\phi + ac\phi) \\ (\dot{\theta}+\dot{\phi})(-bc\phi + as\phi) \\ 0 \end{bmatrix}$$

$${}^B x_C^K = {}^B R^F$$

$${}^N x_C^K = \cancel{{}^N R^B}\, {}^B R^F\, {}^F x_C^K$$

$\theta = 0$

$${}^B R^F = \begin{bmatrix} c\phi & -s\phi \\ s\phi & c\phi \end{bmatrix}$$

$$\begin{bmatrix} c\phi & -s\phi \\ s\phi & c\phi \end{bmatrix} \begin{bmatrix} -b \\ -a \end{bmatrix}$$

$$\dot{x}_B = \dot{x}_K + \omega_B^N \otimes {}^N x_K^B$$

$${}^N x_C^K$$

$$\begin{pmatrix} 0 \\ 0 \\ (\dot{\theta}+\dot{\phi}) \end{pmatrix} \otimes \begin{bmatrix} -bc\phi + as\phi \\ -bs\phi - ac\phi \\ 0 \end{bmatrix} =$$

$$\dot{x}_B = \dot{x}_K + \omega^N_B \times {}^N x^B_K$$

$$\omega^N_B = \begin{bmatrix} 0 \\ 0 \\ \dot{\theta} \end{bmatrix} \otimes \quad {}^N x^B_K = \begin{bmatrix} -k_x \\ -k_y \\ 0 \end{bmatrix}$$

$$\dot{x}_B = \begin{bmatrix} rc\phi\dot{\rho} + (\dot{\theta}+\dot{\phi})[bs\phi + ac\phi] + k_y\dot{\theta} \\ rs\phi\dot{\rho} + (\dot{\theta}+\dot{\phi})[as\phi - bc\phi] - k_x\dot{\theta} \\ \dot{\theta} \end{bmatrix}$$

$$\begin{bmatrix} \dot{x} \\ \dot{y} \\ \dot{\theta} \end{bmatrix} = \begin{bmatrix} bs\phi + ac\phi & rc\phi & (bs\phi + ac\phi) + k_y \\ as\phi - bc\phi & rs\phi & (as\phi - bc\phi) - k_x \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \dot{\phi} \\ \dot{\rho} \\ \dot{\theta} \end{bmatrix}$$