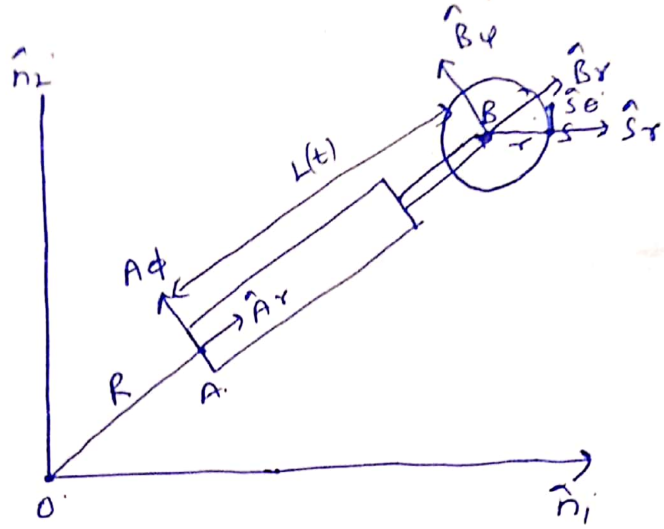

frames defined.
A, B, S

$$\omega_{A/N} = \dot\alpha\, \hat n_3$$

$$\omega_{B/N} = \omega_{B/A} + \omega_{A/N}$$

$$= (\dot\beta + \dot\alpha)\hat n_3$$

$$\omega_{S/N} = (\dot\theta + \dot\alpha + \dot\beta)\hat n_3$$

(a) $\vec r_{S/O} = R\hat A_r + L(t)\hat B_r + r\hat S_r$

Applying Transport theorem.

$$\frac{{}^N d\, \vec r_{S/O}}{dt} = 0 + \omega_{A/N} \times \hat A_r + \dot L(t)\hat B_r + \omega_{B/N}\times \hat B_r + 0 + \omega_{S/N}\times\hat S_r$$

$$\vec V_{S/N} = R\dot\alpha\, \hat n_3 \times \hat A_r + L'(t)\hat B_r + (\dot\alpha + \dot\beta)L(t)\, \hat n_3 \times \hat B_r + r(\dot\theta + \dot\alpha + \dot\beta)\, \hat n_3 \times \hat S_r$$

$$\boxed{\vec V_{S/N} = R\dot\alpha\, \hat A_\phi + L'(t)\hat B_r + L(t)(\dot\alpha + \dot\beta)\hat B_\varphi + r(\dot\theta + \dot\alpha + \dot\beta)\hat S_\theta}$$

(b) To find acceleration Let us apply Transport theorem to $\vec V_{S/N}$

$$\frac{{}^N d}{dt}\vec V_{S/N} = R\ddot\alpha\, \hat A_\phi + (\dot\alpha)\times(R\dot\alpha)(\hat n_3 \times \hat A_\phi) + L''(t)\hat B_r + (\dot\alpha+\dot\beta)\times(L'(t))\, \hat n_3\times\hat B_r + \left[L(t)(\ddot\alpha + \ddot\beta) + (\dot\alpha+\dot\beta)L'(t)\right]\hat B_\varphi + (\dot\alpha+\dot\beta)^2 L(t)\, \hat n_3 \times \hat B_\varphi + r(\ddot\alpha + \ddot\beta)\hat S_\theta + r(\dot\theta + \dot\alpha + \dot\beta)^2\, \hat n_3 \times \hat S_\theta$$

$$\boxed{a_N = R\ddot\alpha\, \hat A_\phi - R(\dot\alpha)^2\hat A_r + \left[L''(t) - (\dot\alpha+\dot\beta)^2 L(t)\right]\hat B_r + \left[(\ddot\alpha+\ddot\beta)L(t) + 2(\dot\alpha+\dot\beta)L'(t)\right]\hat B_\varphi + r(\ddot\alpha+\ddot\beta)\hat S_\theta - r(\dot\theta+\dot\alpha+\dot\beta)^2\hat S_r}$$

(c) $\vec r_{A/S} = -r\hat S_r - L(t)\hat B_r$

$$\omega_{AS} = -\omega_{SA}$$

$$\boxed{V_{A/S} = +r(\dot\theta + \dot\alpha)\hat S_\theta - L'(t)\hat B_r - \dot\alpha L(t)\hat B_\varphi}$$

$$= -[\omega_{SB} + \omega_{BA}]$$

$$= -[\dot\alpha + \dot\beta\theta]$$