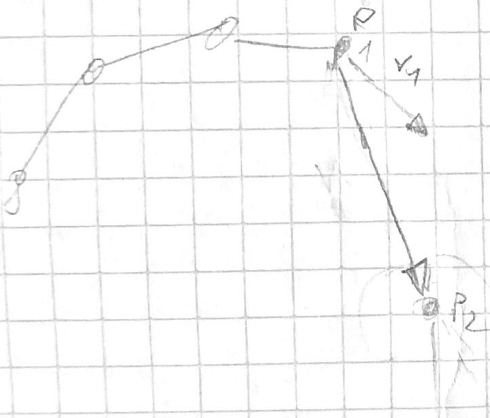
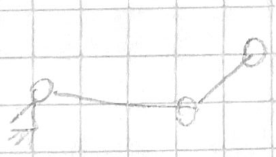


$$v_2 = P_2 - P_1$$

$$e = \frac{v_1^T v_2}{\|v_2\|} - 1 = \cos\alpha - 1$$

$$\dot{e} = \frac{v_1^T \dot{v}_2 + v_2^T \dot{v}_2}{\|v_2\|} - \frac{v_1^T v_2 \left(v_2^T \dot{v}_2\right)}{\left(v_2^T v_2\right)^{3/2}}$$

$$\dot{e} = \underbrace{\left[\frac{\left(v_1^T J_{v_2} + v_2^T J_{v_1}\right)}{\|v_2\|} - \frac{v_1^T v_2 \left(v_2^T J_{v_2}\right)}{\left(v_2^T v_2\right)^{3/2}}\right]}_{J_T} \dot{q}$$



$$J_{v_2} = J_{P_2} - J_{P_1}$$

$$J_{v_{1_i}} = k_i \times v_1$$

$$\dot{J}_{v_2} = \dot{J}_{P_2} - \dot{J}_{P_1}$$

$$\dot{J}_T = \frac{\dot{v}_1^T J_{v_2} + v_1^T \dot{J}_{v_2} + \dot{v}_2^T J_{v_1} + v_2^T \dot{J}_{v_1}}{\|v_2\|} - \frac{\left[v_1^T J_{v_2} + v_2^T J_{v_1}\right]\left(v_2^T \dot{v}_2\right)}{\left(v_2^T v_2\right)^{3/2}} -$$

$$- \frac{\left[\dot{v}_1^T v_2 + \dot{v}_2^T v_1\right] v_2^T J_{v_2}}{\left(v_2^T v_2\right)^{3/2}} - \frac{v_1^T v_2 \, \dot{v}_2^T J_{v_2}}{\left(v_2^T v_2\right)^{3/2}} - \frac{v_1^T v_2 \, v_2^T \dot{J}_{v_2}}{\left(v_2^T v_2\right)^{3/2}} +$$

$$+ \frac{3\left(v_1^T v_2\right) v_2^T J_{v_2} \left(v_2^T \dot{v}_2\right)}{\left(v_2^T v_2\right)^{5/2}}$$