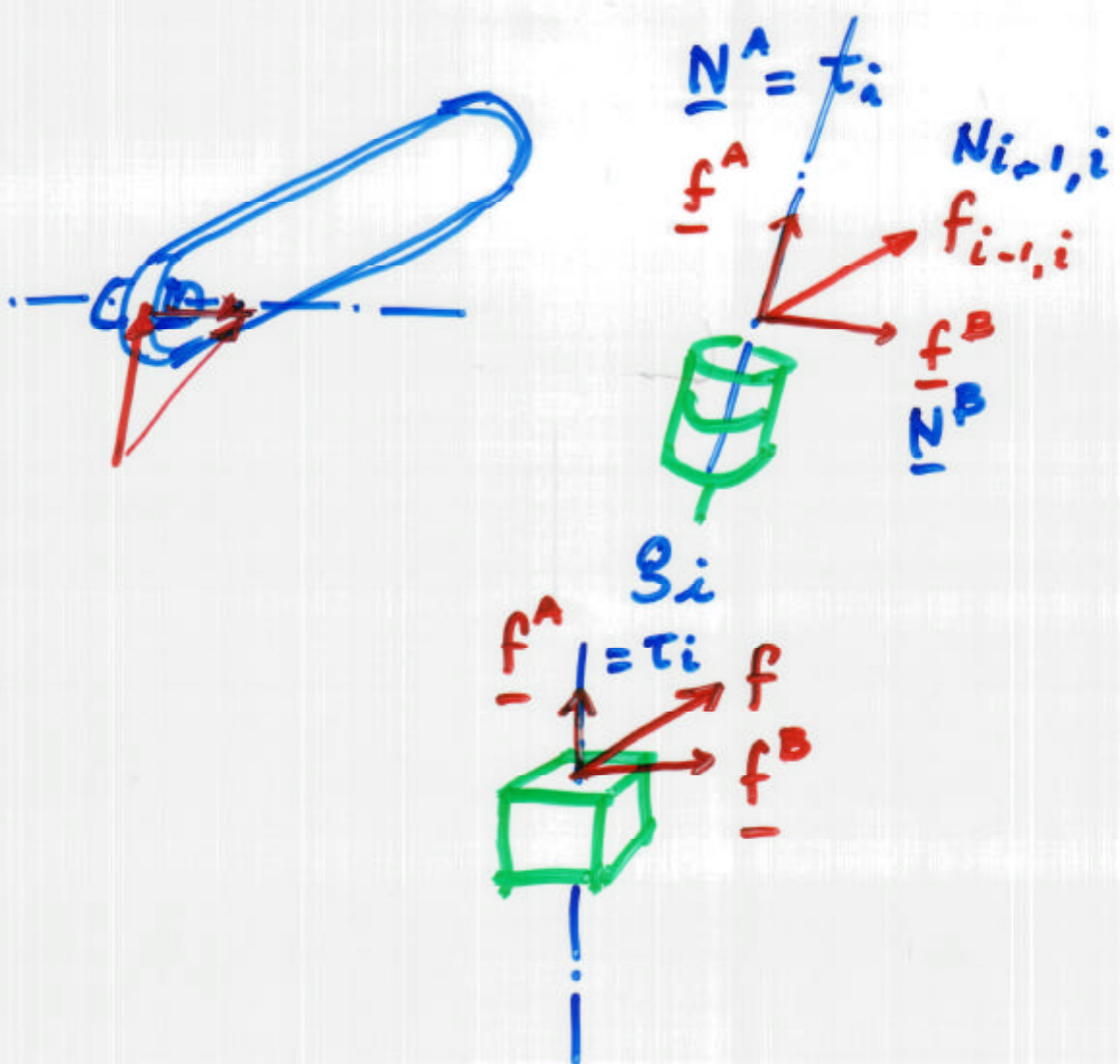
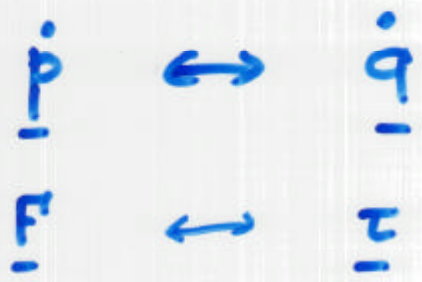
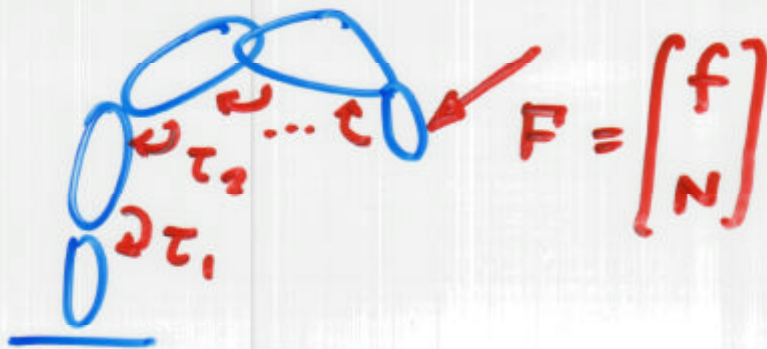






LAVORI VIRTUALI

$$\underline{F}^T \cdot \underline{\Delta p} = \delta W_p$$

$$\begin{array}{c} \underline{F}^T \cdot \underline{\delta p} \\ \text{1x6} \quad \text{6x1} \end{array} = 1$$

$$\sum_{i=1}^6 \tau_i \delta q_i = [\tau_1 \dots \tau_6] \begin{bmatrix} \delta q_1 \\ \vdots \\ \delta q_6 \end{bmatrix} =$$

$$= \underline{\tau}^T \underline{\delta q}$$

$$\boxed{\underline{F}^T \underline{\delta p} = \underline{\tau}^T \underline{\delta q} \quad \text{equivalenti} \quad (1)}$$

3

$$\boxed{\underline{F}^T \delta \underline{p} = -\tau^T \delta q} \quad (2)$$

equilibrante

$$\delta p = J \delta q \quad \dot{p} = J \dot{q}$$

$$\cancel{F^T J} \cancel{\delta q} = \cancel{\tau^T} \cancel{\delta q} \quad \text{dalla (1)}$$

$$F^T J = \tau^T$$

$$\boxed{\tau = J^T F}$$

$$\tau(t) = J^T(q(t)) F(t)$$

se J $n \times n$ anche J^T $n \times n$

$$\underline{F} = J^{-T} \underline{\tau}$$

RELAZ. CINETO-STATICHE

101 - 103

CEDevolezza sinonimo
di Comportamento
elastico

1) NEI GIUNTI

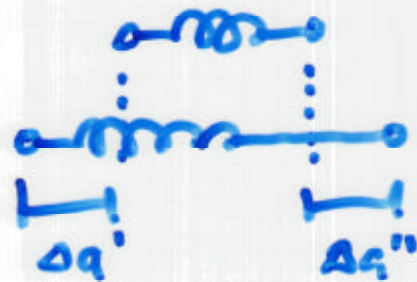
- ASSE DI ROTAZIONE
- RIDUTTORI

2) NEI BRACCI

3) NEL CONTROLLO

— o —

$$\tau_{ei} = k_i \Delta q_i$$



$$\underline{\tau}_e = K_q \underline{\Delta q}$$

$$\Delta q = \Delta q' + \Delta q''$$

$$K_q = \begin{bmatrix} k_1 & & \phi \\ & k_2 & \dots \\ \phi & & k_6 \end{bmatrix}$$

$$\underline{\Delta q} = K_q^{-1} \underline{\tau}_e$$

5

$$\tau_e = J^T F$$

$$\Delta p \approx J \Delta q \quad (\dot{p} = J \dot{q})$$

$$\Delta p = J \Delta q = J K_q^{-1} \tau_e = \underbrace{J K_q^{-1} J^T}_{C_p} F$$

$$\Delta p = K_p^{-1} F$$

$$K_p^{-1} = J K_q^{-1} J^T$$

$$C_p = J C_q J^T$$

C_p, C_q
Cedevoletta

$$C_q = \begin{bmatrix} \frac{1}{k_1} & & \\ & \frac{1}{k_2} & \\ & & \dots \end{bmatrix}$$

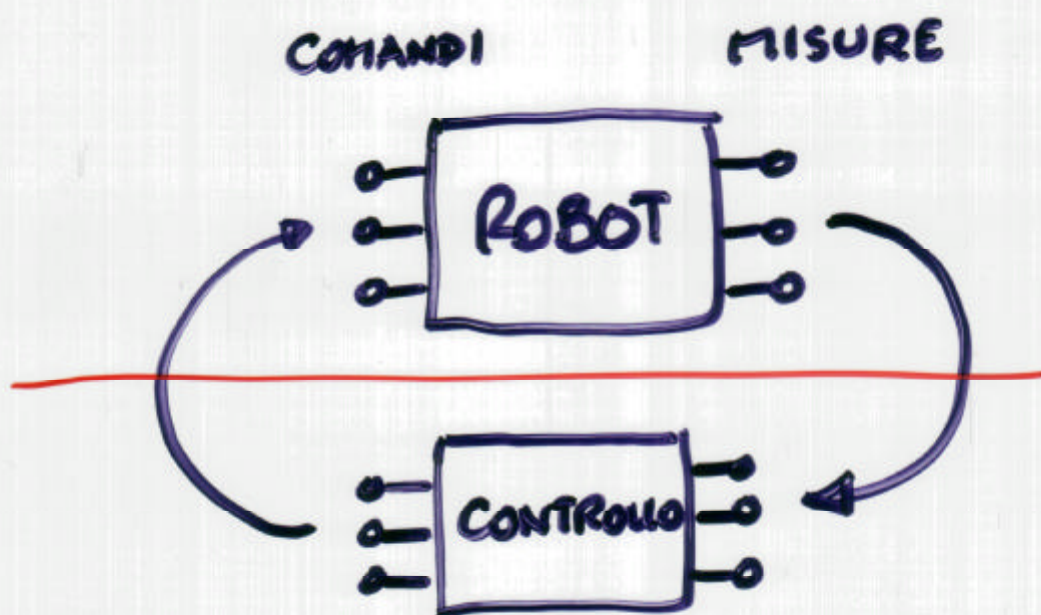
$$\Delta p = C_p F \iff F = C_p^{-1} \Delta p = K_p \Delta p$$

DINAMICA DEL MANIPOLATORE

⇒ MODELLO

6

CAUSE ↔ EFFETTI



NEWTON/EULERO

FORZE + COPPIE

• **EQUILIBRIO
DINAMICO**

DI FORZE & MOMENTI

EQ. VETTORIALI

6 + 6

LAGRANGE

**ENERGIA
CINETICA &
POTENZIALE**

EQ. SCALARI

6