Lezione 10/03/2004

a) Interazione con l'ambiente: testo pagg. 97-100
b) Sorgenti di elasticità nel robot: testo pag. 103
c) Cedevolezza del robot: testo pagg. 103-106

STATICA

FORZE ; MOMENTI / COPPIE

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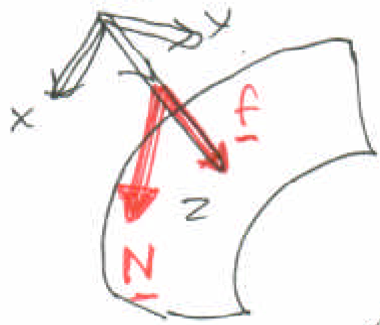
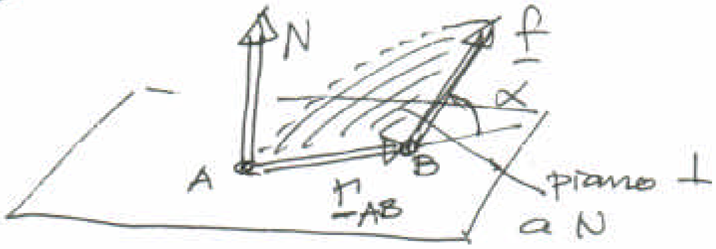
FORZE "CARTESIANE"
GENERALIZZATE

$$\underline{F} \; ; \; \underline{f} = \begin{bmatrix} f_x \\ f_y \\ f_z \\ \hdashline N_x \\ N_y \\ N_z \end{bmatrix} \begin{array}{l} \left.\begin{array}{l} \\ \\ \\ \end{array}\right\} \text{Forza lineare} \\ \left.\begin{array}{l} \\ \\ \\ \end{array}\right\} \text{Momento} \end{array}$$

PUNTA MANIPOLATORE





$$\underline{N} = \underline{r} \times \underline{f} = \|\underline{r}\| \cdot \|\underline{f}\| \cdot \sin\alpha$$

FORZE "GENERALIZZATE" INTERNE

$$\underline{\tau} = \begin{bmatrix} \tau_1 \\ \tau_2 \\ \vdots \\ \tau_6 \end{bmatrix}$$

$\tau_4 = -2\ N$

$\tau_2 = 5\ Nm$

τ_i è diretto lungo $\underline{k}_{i-1}$

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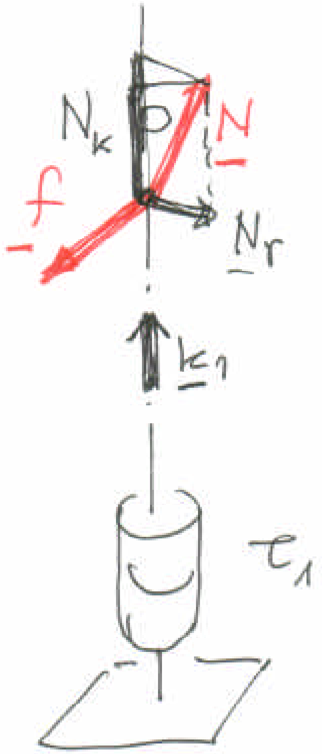
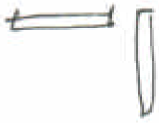


$\underline{f}$ tutta equilibrata dalla struttura meccanica

prodotto scalare

$$N_k = \underline{k}_1 \cdot \underline{N} = \underline{k}_1^T \underline{N} = \underline{N}^T \underline{k}_1$$



$$\pm \tau_1 \underline{k} = N_k \underline{k}$$

$\underline{N}_r$ è equilibrato dalla struttura

$\tau_1 = +N_k$ forza gen. interna equivalente

$\tau_1 = -N_k$ " " " equilibrante

POTENZA

$\tau \omega$ $\underline{\tau} \cdot \underline{\omega}$

i-esimo giunto

$\tau_i \dot{q}_i$ = potenza istantanea

PRINCIPIO LAVORI VIRTUALI

③

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$$\underline{\tau} = \begin{bmatrix} \tau_1 \\ \vdots \\ \tau_6 \end{bmatrix} \qquad \underline{q} = \begin{bmatrix} q_1 \\ \vdots \\ q_6 \end{bmatrix}$$

Giunti $\delta L_q = \underline{\tau}^T \, \delta \underline{q}$ = variabile scalare

$$F = \begin{bmatrix} \underline{f} \\ \hdashline \underline{N} \end{bmatrix} \qquad \underline{p} = \begin{bmatrix} p_1 \\ p_3 \\ \hline \alpha_1 \\ \vdots \\ \alpha_3 \end{bmatrix}$$

$\delta L_p = F^T \delta p$ =variabile scalare

$$\underbrace{F^T \delta p}_{\underline{f}^T \delta p_L + \underline{N}^T \delta \underline{\alpha}}$$

$$\boxed{\delta L_p = \delta L_q}$$

$$\dot{\underline{p}} = J \dot{\underline{q}}$$

$$\frac{d\underline{p}}{dt} = J \frac{d\underline{q}}{dt}$$

$$d\underline{p} = J \, d\underline{q}$$

$$\delta p = J \, \delta q$$

$$\left.\begin{array}{l} \delta L_p = F^T \delta p = F^T J \delta q \\ \delta L_q = \tau^T \delta q \end{array}\right\} \Rightarrow F^T J = \tau^T$$

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

EQUIVALENZA

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

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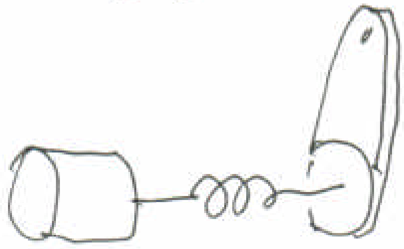
pagg $97 \div 101$

RIGIDEZZA INFINITA

ELEMENTI CHE INTRODUCONO EFFETTI ELASTICI

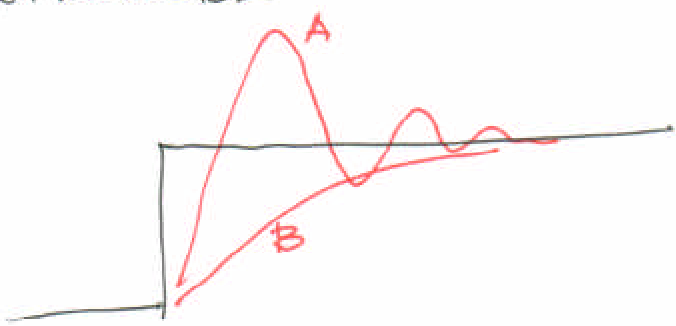
1) BRACCI → MANIPOLATORI SPAZIALI

2) GIUNTI



SCATOLE DI RIDUZIONE
MOTORIDUTTORI

3) CONTROLLORE



Hip. elasticità ē concentrata nei giunti

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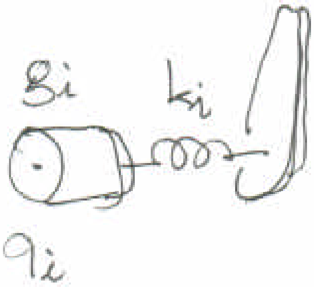

$$\tau_i = k_i q_i = k_i \Delta q_i$$

$$\underline{\tau}_e = \begin{bmatrix} k_1 & & \phi \\ & \ddots & \\ \phi & & k_6 \end{bmatrix} \begin{bmatrix} \underline{q} \end{bmatrix} = K_q \Delta \underline{q}$$

$$\Delta \underline{q} = K_q^{-1} \underline{\tau}_e \qquad \dot{p} = J \dot{q}$$

$$\tau_e = J^T F_e \qquad \Delta p \simeq J \Delta q$$

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

C_p cedevolezza

$C_p^{-1} \rightarrow$ matrice di rigidezza

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

$$\tau_e = K_q \Delta q$$

$$K_p = \left[J K^{-1} J^T \right]^{-1}$$

$$= (J^T)^{-1} K (J)^{-1}$$