Università delgi studi di Roma la Sapienza

Meccanica applicata alel macchine per
gli allievi del corso di Ingegneria Meccanica
A.A. 2008 - 2009

METODO ANALITICO ESATTO

RIEPILOGO DELLE FORMULE USATE

Materiale di supporto per l'esercitazione

$$\omega4 := \frac{\omega2\, r_2 \sin(\theta2 - \theta3)}{r_4 \sin(-\theta4 + \theta3)}$$

$$\omega3 := -\frac{\omega2\, r_2 \sin(\theta2 - \theta4)}{r_3 \sin(-\theta4 + \theta3)}$$

$$\alpha4 := \frac{\alpha2\, r_2 \sin(\theta2 - \theta3) + \omega2^2\, r_2 \cos(\theta2 - \theta3) + \frac{\omega2^2\, r_2^2 \sin(\theta2 - \theta4)^2}{r_3 \sin(-\theta4 + \theta3)^2} + \frac{\omega2^2\, r_2^2 \sin(\theta2 - \theta3)^2 \cos(-\theta4 + \theta3)}{r_4 \sin(-\theta4 + \theta3)^2}}{r_4 \sin(-\theta4 + \theta3)}$$

$$\alpha3 := -\frac{\alpha2\, r_2 \sin(\theta2 - \theta4) + \omega2^2\, r_2 \cos(\theta2 - \theta4) + \frac{\omega2^2\, r_2^2 \sin(\theta2 - \theta3)^2}{r_4 \sin(-\theta4 + \theta3)^2} + \frac{\omega2^2\, r_2^2 \sin(\theta2 - \theta4)^2 \cos(-\theta4 + \theta3)}{r_3 \sin(-\theta4 + \theta3)^2}}{r_3 \sin(-\theta4 + \theta3)}$$

Analisi cinematica del quadrilatero articolato

Analisi delle posizioni per un assegnato angolo dell'asta movente

r1 = telaio
r2 = asta movente
r3 = biella
r4 = asta cedente (bilanciere o manovella)

$$\theta_1 := \pi$$

$$chiusura_1 := -r_1 + r_2 \cos(\theta_2) + r_3 \cos(\theta_3) + r_4 \cos(\theta_4) = 0$$

$$chiusura_2 := r_2 \sin(\theta_2) + r_3 \sin(\theta_3) + r_4 \sin(\theta_4) = 0$$

$$equaz := -r_3^2 + (r_1 - r_2 \cos(\theta_2) - r_4 \cos(\theta_4))^2 + (-r_2 \sin(\theta_2) - r_4 \sin(\theta_4))^2$$

$$equaz := -r_3^2 + r_1^2 - 2 r_1 r_2 \cos(\theta_2) - 2 r_1 r_4 \cos(\theta_4) + 2 r_2 \cos(\theta_2) r_4 \cos(\theta_4) + r_2^2 + 2 r_2 \sin(\theta_2) r_4 \sin(\theta_4) + r_4^2$$

$$equaz1 := (2 r_2 \cos(\theta_2) r_4 - 2 r_1 r_4) \cos(\theta_4) - r_3^2 + r_1^2 - 2 r_1 r_2 \cos(\theta_2) + r_4^2 + r_2^2 + 2 r_2 \sin(\theta_2) r_4 \sin(\theta_4)$$

$$A := 2 r_2 \cos(\theta_2) r_4 - 2 r_1 r_4$$

$$B := 2 r_2 \sin(\theta_2) r_4$$

$$C := -r_3^2 + r_1^2 - 2 r_1 r_2 \cos(\theta_2) + r_4^2 + r_2^2$$

$$\theta 2 := 0.3490658504$$

$$\omega 2 := 41.88790204$$

$$\alpha 2 := 0$$

$$t2 := 0.3490658504$$

$$r_1 := 80$$

$$r_2 := 20$$

$$r_3 := 50$$

$$r_4 := 70$$

$$(2800. \cos(\theta_2) - 11200.) \cos(\theta_4) + 9200. - 3200. \cos(\theta_2) + 2800. \sin(\theta_2) \sin(\theta_4)$$

$$equaz2 := \frac{(2800 \cos(\theta_2) - 11200)(1 - t42^2)}{1 + t42^2} + 9200 - 3200 \cos(\theta_2) + 2800 \sin(\theta_2) \sin(\theta_4)$$

$$equaz3 := \frac{(2800 \cos(\theta_2) - 11200)(1 - t42^2)}{1 + t42^2} + 9200 - 3200 \cos(\theta_2) + \frac{5600 \sin(\theta_2)\, t42}{1 + t42^2}$$

$$soluzioni := \frac{1}{2\left(75 \sin(\theta_2)^2 + 792\right)} \Big(-70 \sin(\theta_2) \cos(\theta_2) - 238 \sin(\theta_2)$$

$$+ 2\, \mathrm{sqrt}\Big($$

$1225 \sin(\theta_2)^2 \cos(\theta_2)^2 + 11480 \sin(\theta_2)^2 \cos(\theta_2) + 16951 \sin(\theta_2)^2 - 375 \sin(\theta_2)^4 + 71280$

$+ 33264 \cos(\theta_2)\Big)\Big)$,

$$\frac{1}{2\left(75 \sin(\theta_2)^2 + 792\right)}\Big(-70 \sin(\theta_2) \cos(\theta_2) - 238 \sin(\theta_2)$$

$- 2 \operatorname{sqrt}\Big($

$1225 \sin(\theta_2)^2 \cos(\theta_2)^2 + 11480 \sin(\theta_2)^2 \cos(\theta_2) + 16951 \sin(\theta_2)^2 - 375 \sin(\theta_2)^4 + 71280$

$+ 33264 \cos(\theta_2)\Big)\Big)$

tang_theta_4_mezzi_1 :=

$$\frac{35 \sin(\theta_2) \cos(\theta_2) + 119 \sin(\theta_2) - 2 \sqrt{2} \sqrt{-\left(8 \cos(\theta_2)^2 + 3 \cos(\theta_2) - 38\right) (5 \cos(\theta_2) + 17)^2}}{3\left(-289 + 25 \cos(\theta_2)^2\right)}$$

tang_theta_4_mezzi_2 :=

$$\frac{35 \sin(\theta_2) \cos(\theta_2) + 119 \sin(\theta_2) + 2 \sqrt{2} \sqrt{-\left(8 \cos(\theta_2)^2 + 3 \cos(\theta_2) - 38\right) (5 \cos(\theta_2) + 17)^2}}{3\left(-289 + 25 \cos(\theta_2)^2\right)}$$

Inizio della procedura di calcolo PER IL QUADRILATERO

$$cos\_t3 := \frac{8}{5} - \frac{2}{5} \cos(\theta_2) - \frac{7}{5} \cos(\theta_4)$$

$$sin\_t3 := -\frac{2}{5} \sin(\theta_2) - \frac{7}{5} \sin(\theta_4)$$

tang_t4_mezzi_1 := 0.3415198560

t4_1 := 0.6582004832

ct3_1 := 0.116590980

st3_1 := -.9931800153

tang_t4_mezzi_2 := -.4712673840

$t4\_2 := -.8807969084$

$ct3\_2 := 0.3329715248$

$st3\_2 := 0.9429368817$

VALORI NUMERICI

70.55076539

$t3 := 1.231343146$

0

$\omega 4 := -10.78335923$

$\omega 3 := -18.42528424$

$\alpha 4 := 584.7107578$

$\alpha 3 := -259.6554635$

$l_1 := 80$

$l_2 := 20$

$l_3 := 50$

$l_4 := 70$

GRAFICO DEL QUADRILATERO

```
Warning, the previous binding of the name CrossProduct has been removed
and it now has an assigned value
```

$rag\_cer := 1$

$quadri := \{\}$

$Ax := 0$

$Ay := 0$

$Bx := 18.79385242$

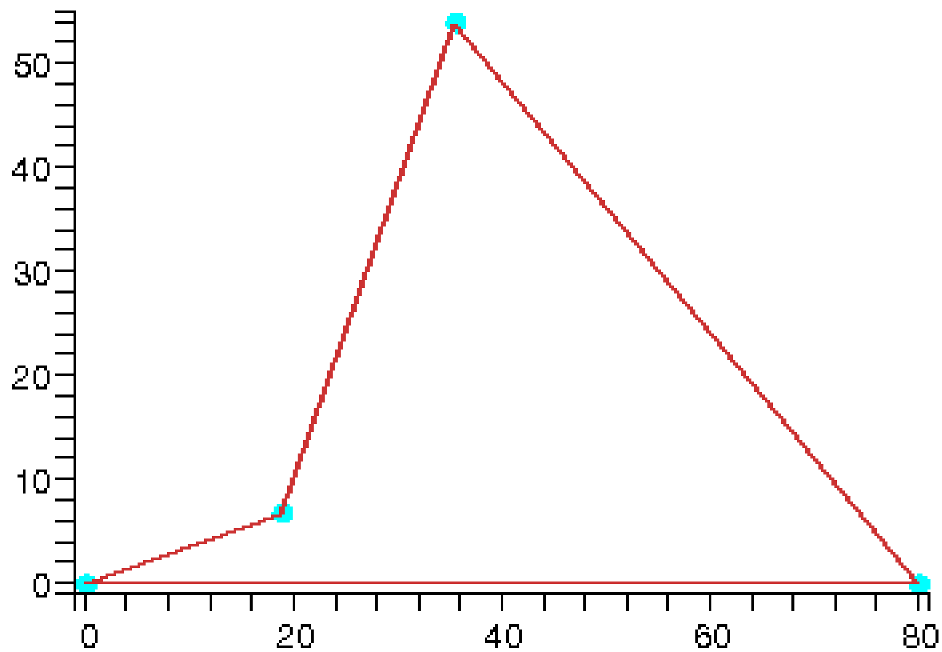
$By := 6.840402866$

$Cx := 35.44242866$

$Cy := 53.98724695$

$Dx := 80$

$Dy := 0$



Individuazione del quadrilatero articolato (ovvero degli infiniti quadrilateri articolati)

20.00000000

49.99999998

69.99999998

80.00000000

G2

G3

G4

name of the object: CP form of the object: point2d coordinates of the point: [35.44242866, 53.987

name of the object: G2 form of the object: point2d coordinates of the point: [9.396926210, 3.4202

$$PG2 := \begin{bmatrix} 9.396926210 \\ 3.420201433 \end{bmatrix}$$

$$\Omega_2 := \begin{bmatrix} 0 & -41.88790204 \\ 41.88790204 & 0 \end{bmatrix}$$

$$VG2 := \begin{bmatrix} -143.265062582571630 \\ 393.617524561588482 \end{bmatrix}$$

$$\Omega_3 := \begin{bmatrix} 0 & 18.42528424 \\ -18.42528424 & 0 \end{bmatrix}$$

$$PB := \begin{bmatrix} 18.7938524200000004 \\ 6.84040286599999980 \end{bmatrix}$$

$$BG3x := 8.324288150$$

$$BG3y := 23.57342204$$

$$BG3 := \begin{bmatrix} 8.324288150 \\ 23.57342204 \end{bmatrix}$$

$$PG3 := \begin{bmatrix} 27.1181405700000013 \\ 30.4138249060000021 \end{bmatrix}$$

$$VG3\_B := \begin{bmatrix} 434.347001596480652 \\ -153.377375259413753 \end{bmatrix}$$

$$VB := \begin{bmatrix} -286.530125165143260 \\ 787.235049123176964 \end{bmatrix}$$

$$VG3 := \begin{bmatrix} 147.816876431337392 \\ 633.857673863763239 \end{bmatrix}$$

$$VC := \begin{bmatrix} 582.163878027818100 \\ 480.480298604349457 \end{bmatrix}$$

$$PC := \begin{bmatrix} 35.4424287199999953 \\ 53.9872469459999990 \end{bmatrix}$$

$$CG4x := 22.27878568$$

$$CG4y := -26.99362348$$

$$CG4 := \begin{bmatrix} 22.27878568 \\ -26.99362348 \end{bmatrix}$$

$$PG4 := \begin{bmatrix} 57.7212143999999938 \\ 26.9936234659999990 \end{bmatrix}$$

$$\Omega_4 := \begin{bmatrix} 0 & 10.78335923 \\ -10.78335923 & 0 \end{bmatrix}$$

$$VG4\_C := \begin{bmatrix} -291.081938904202730 \\ -240.240149195619807 \end{bmatrix}$$

$$VG4 := \begin{bmatrix} 291.081939123615371 \\ 240.240149408729650 \end{bmatrix}$$

$scala\_V := 0.02$

$ext\_V2\_x := 6.531624958$

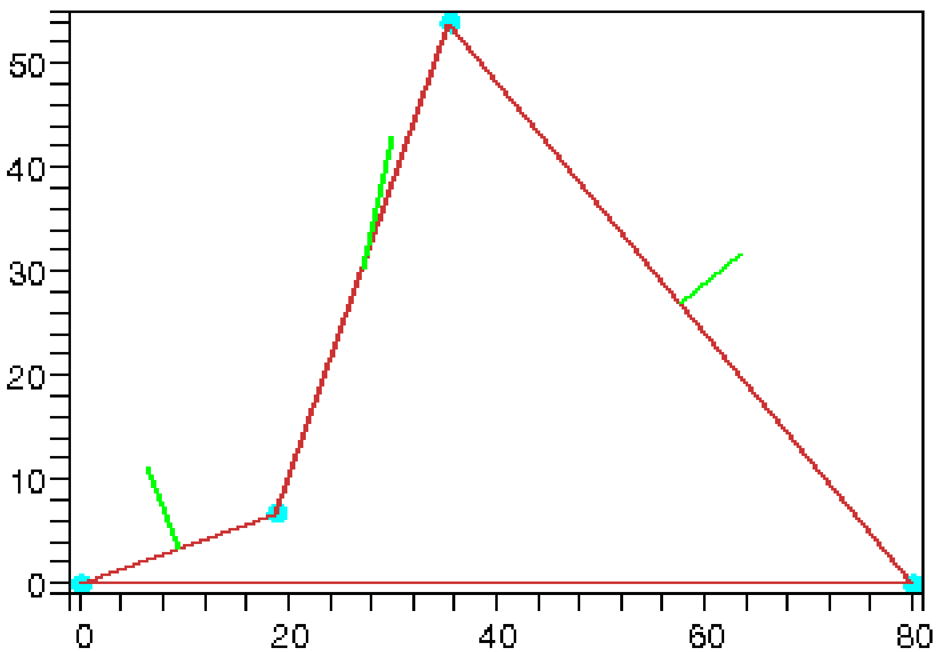
$ext\_V2\_y := 11.29255192$

$ext\_V3\_x := 30.07447810$

$ext\_V3\_y := 43.09097839$

$ext\_V4\_x := 63.54285318$

$ext\_V4\_y := 31.79842646$



$$A2 := \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix}$$

$$A3 := \begin{bmatrix} 0 & 259.6554635 \\ -259.6554635 & 0 \end{bmatrix}$$

$$A4 := \begin{bmatrix} 0 & -584.7107578 \\ 584.7107578 & 0 \end{bmatrix}$$

$$scala\_A := 0.0005$$

$$AG2 := \begin{bmatrix} -16487.8123100631128 \\ -6001.07290721322988 \end{bmatrix}$$

$$ext\_A2\_x := 1.153020055$$

$$ext\_A2\_y := 0.419664979$$

EA2P

AcG2

$$AcB := \begin{bmatrix} -32975.6246201262256 \\ -12002.1458144264598 \end{bmatrix}$$

$$AG3 := \begin{bmatrix} -29680.6785291887500 \\ -22166.5596755291590 \end{bmatrix}$$

$$AcC := \begin{bmatrix} -26385.7324382512816 \\ -32330.9735366318564 \end{bmatrix}$$

$$ext\_A3\_x = 12.27780131$$

$$ext\_A3\_y = 19.33054507$$

$$EA3P$$

$$AcG3$$

$$DG4 := \begin{bmatrix} -22.2787856000000062 \\ 26.9936234659999990 \end{bmatrix}$$

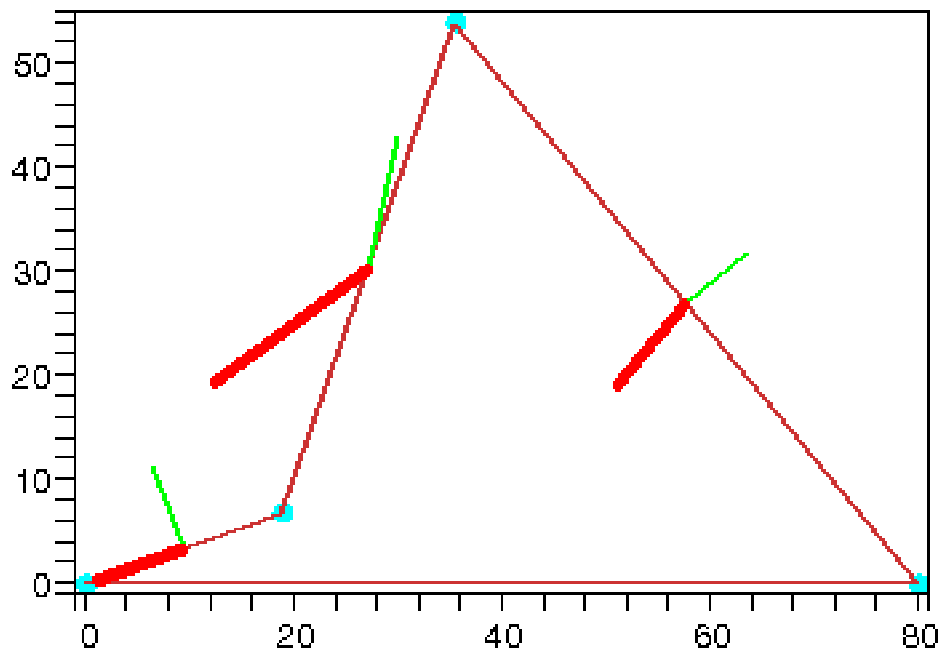
$$AG4 := \begin{bmatrix} -13192.8662116300257 \\ -16165.4867219807311 \end{bmatrix}$$

$$ext\_A4\_x = 51.12478130$$

$$ext\_A4\_y = 18.91088011$$

$$EA4P$$

$$AcG4$$



50
40
30
20
10
0
0
20
40
60
80