Mecanismos

Mecanismos com 1 GL
com cadeia composta

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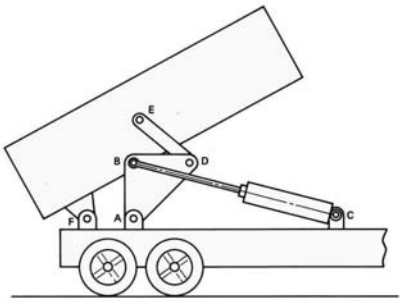
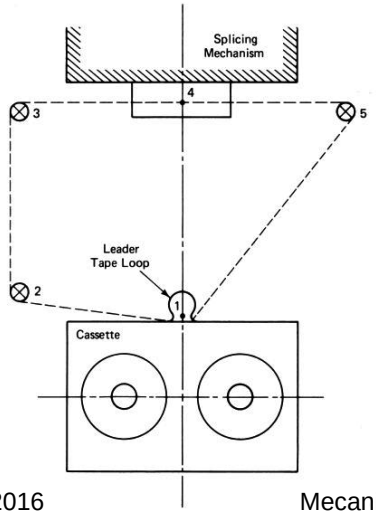


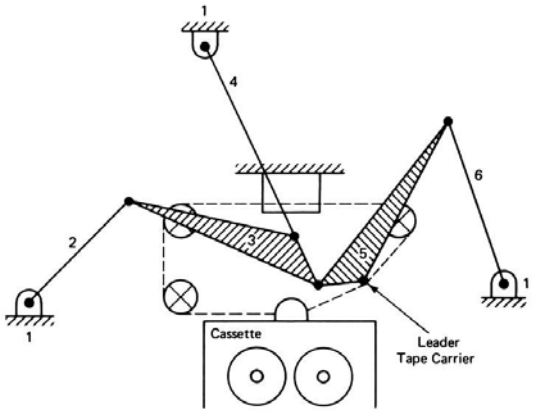
Conteúdo

- Definição de cadeia composta
- Análise geral
- Grafo
- Exemplo: puncionadeira
  - Posições extremas

Definição

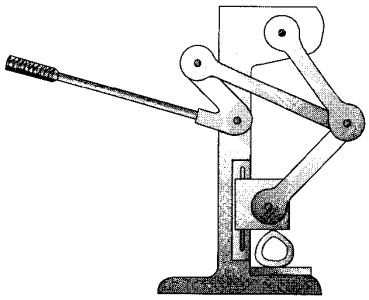
São mecanismos que possuem mais de um circuito em sua cadeia cinemática.

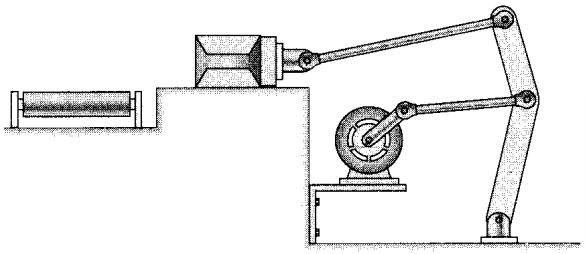


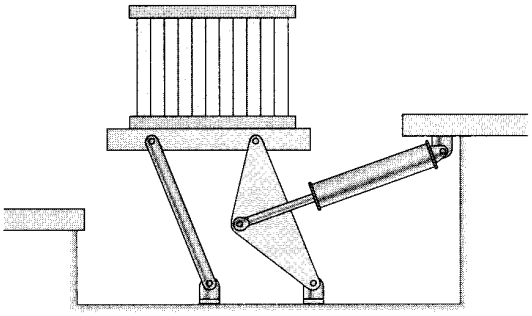


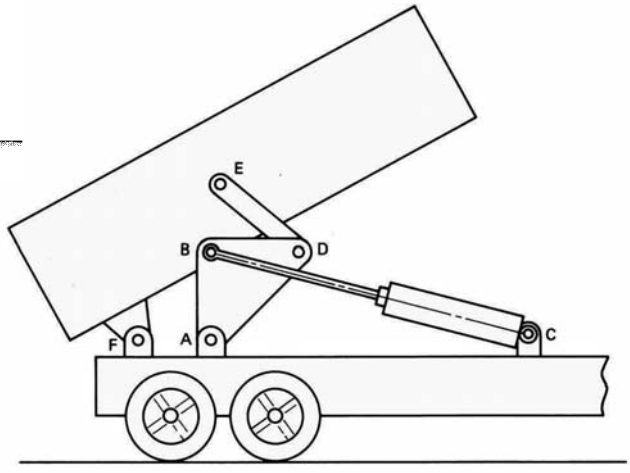
Finalidades

- Produzir movimentos complexos
- Produzir força adequada

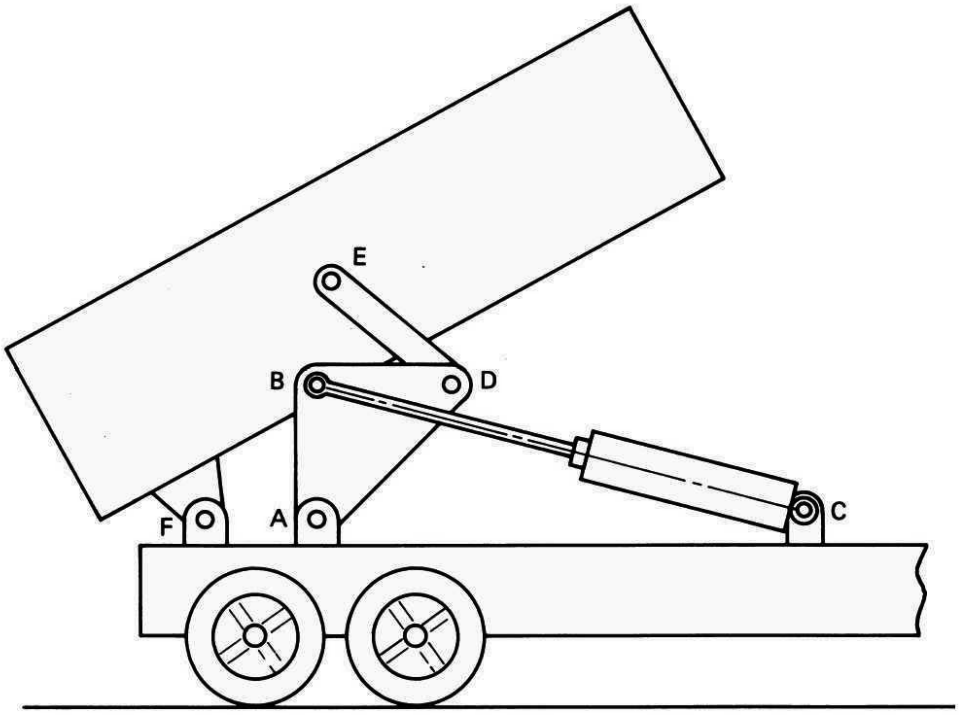




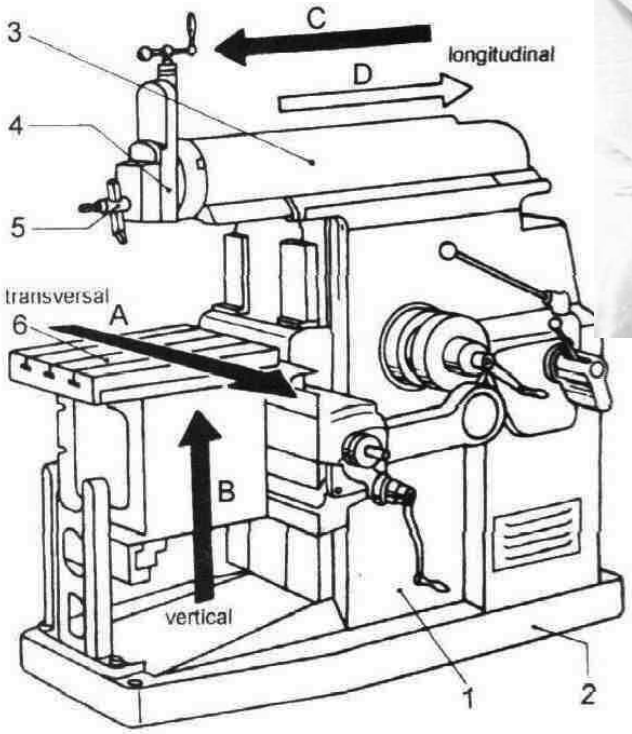


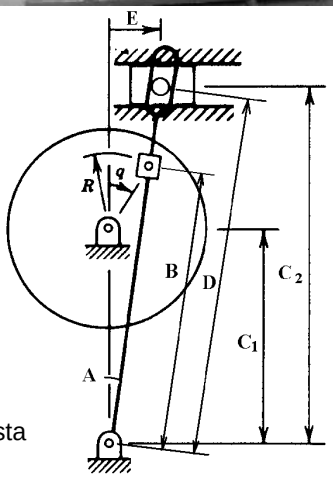


Exemplo: acionamento de caçamba

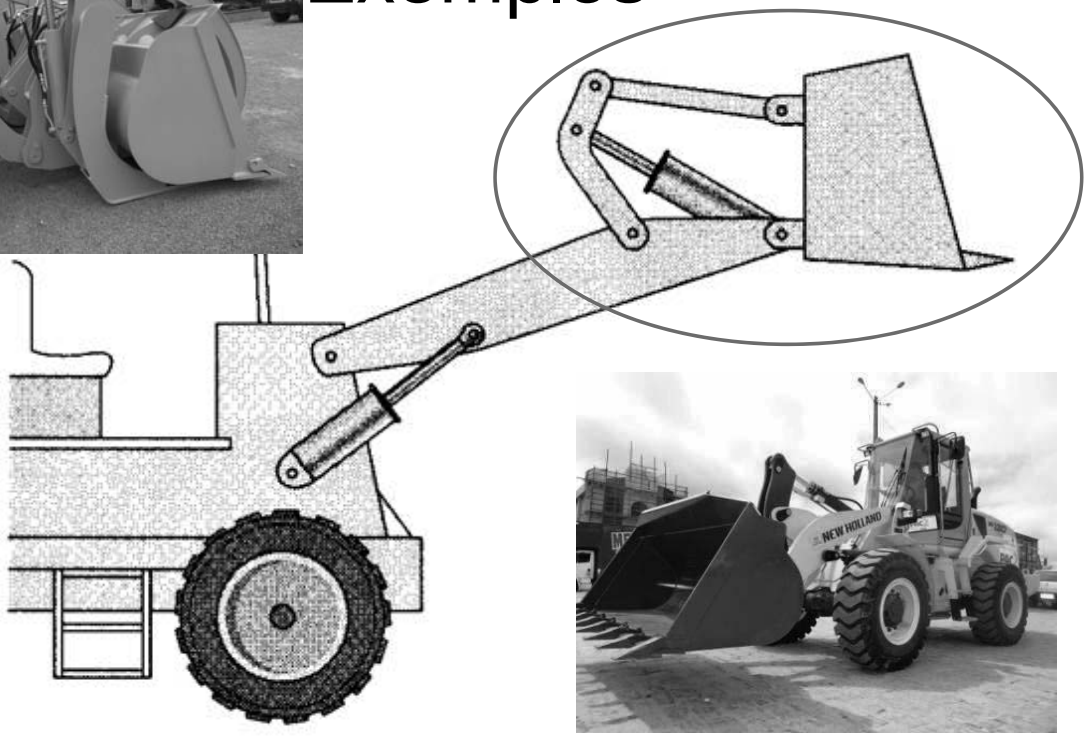


Exemplo: plaina

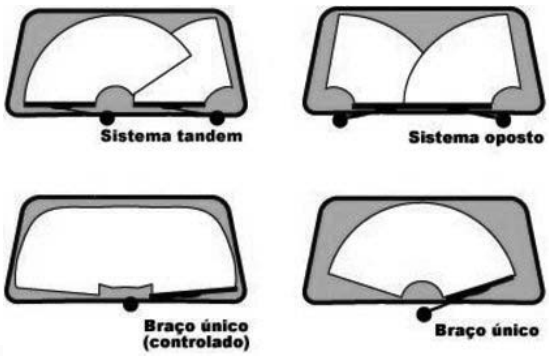


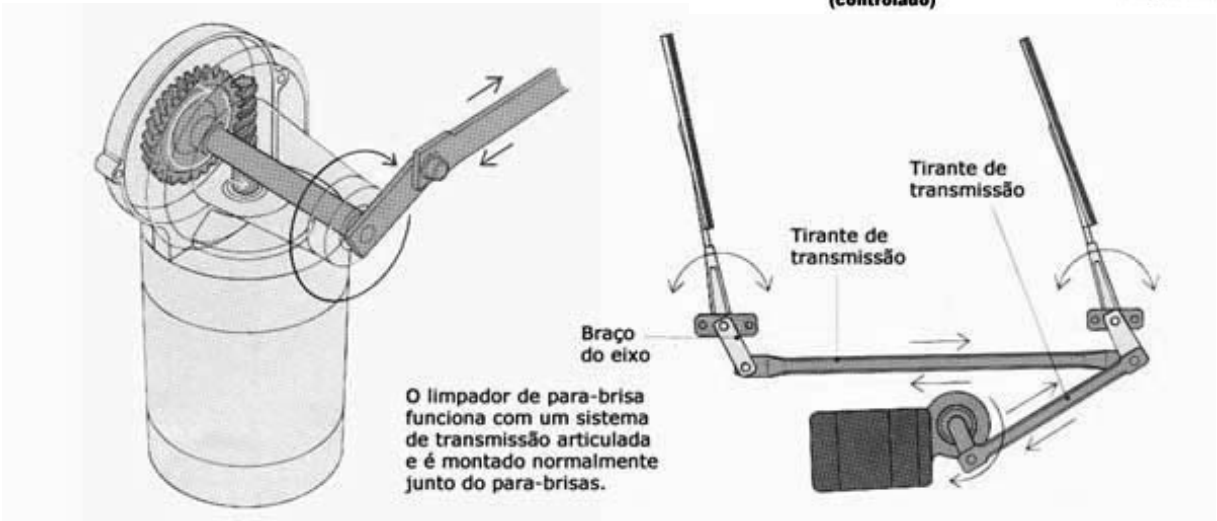


Exemplos



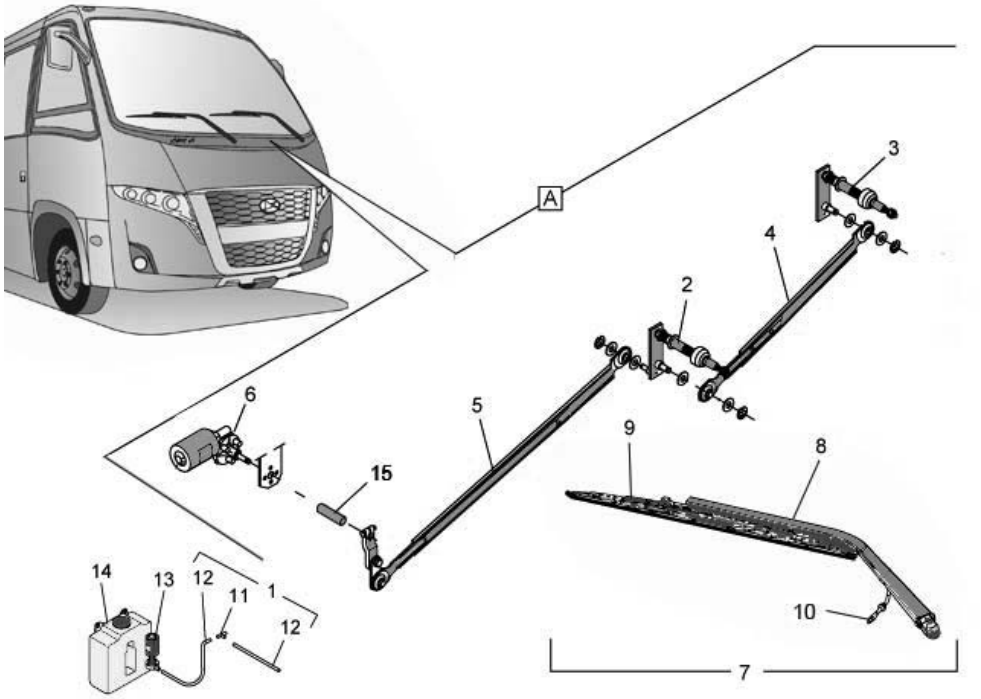
Exemplos
Limpador de para-brisa





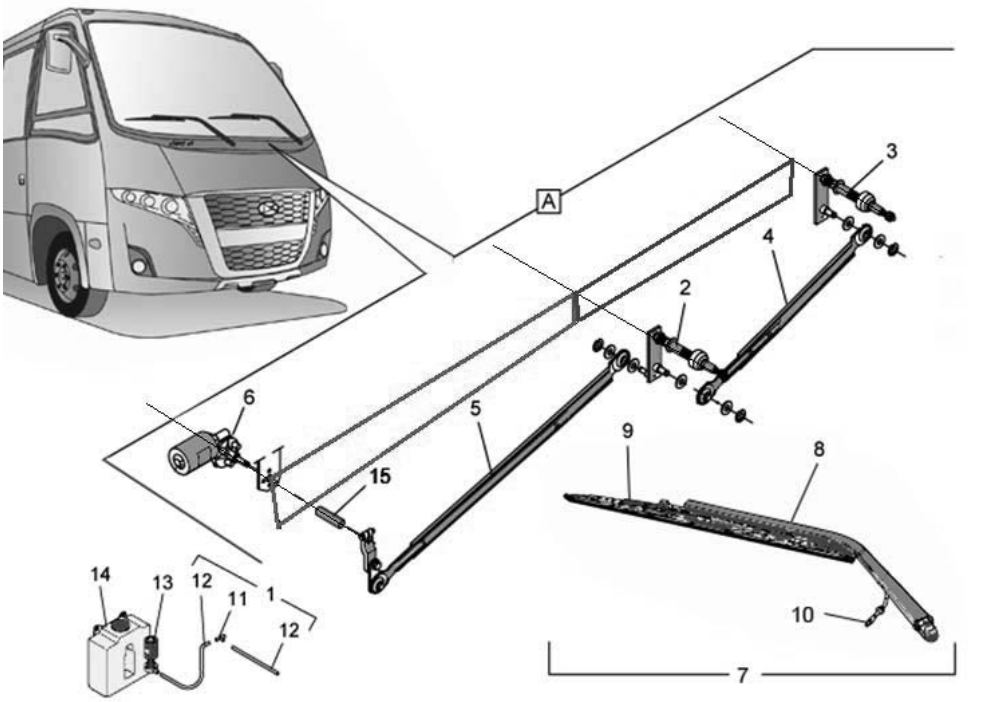
Exemplos

Limpador de para-brisa



Exemplos

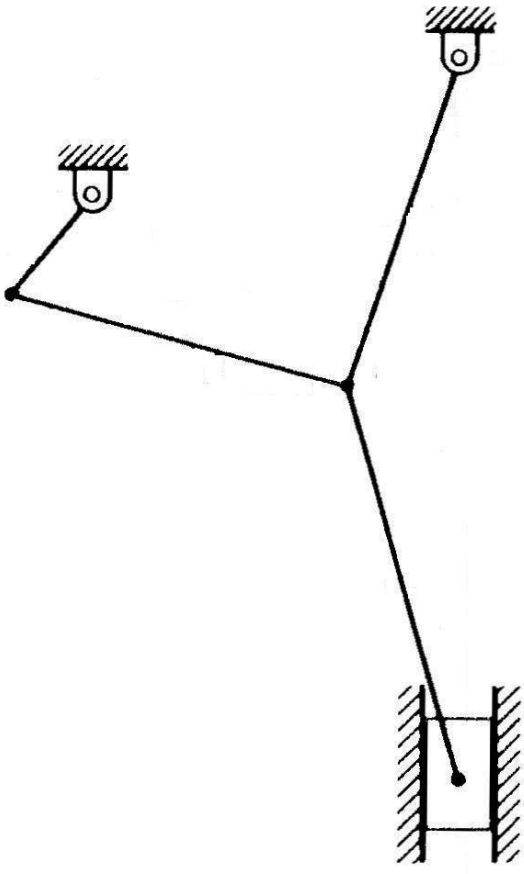
Limpador de para-brisa



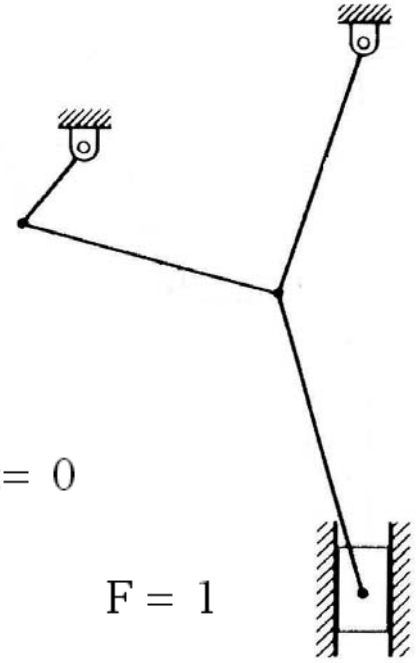
Exemplos

Limpador de para-brisa

Análise de uma puncionadeira



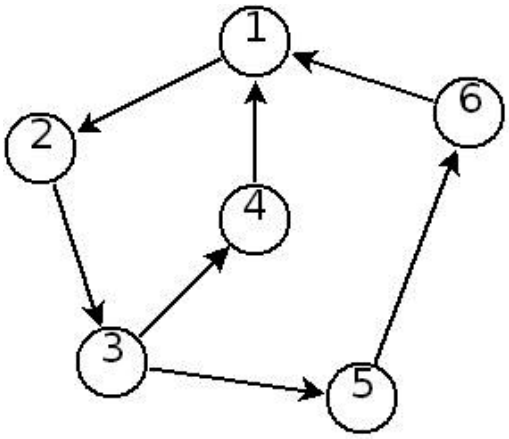
1. Número de graus de liberdade

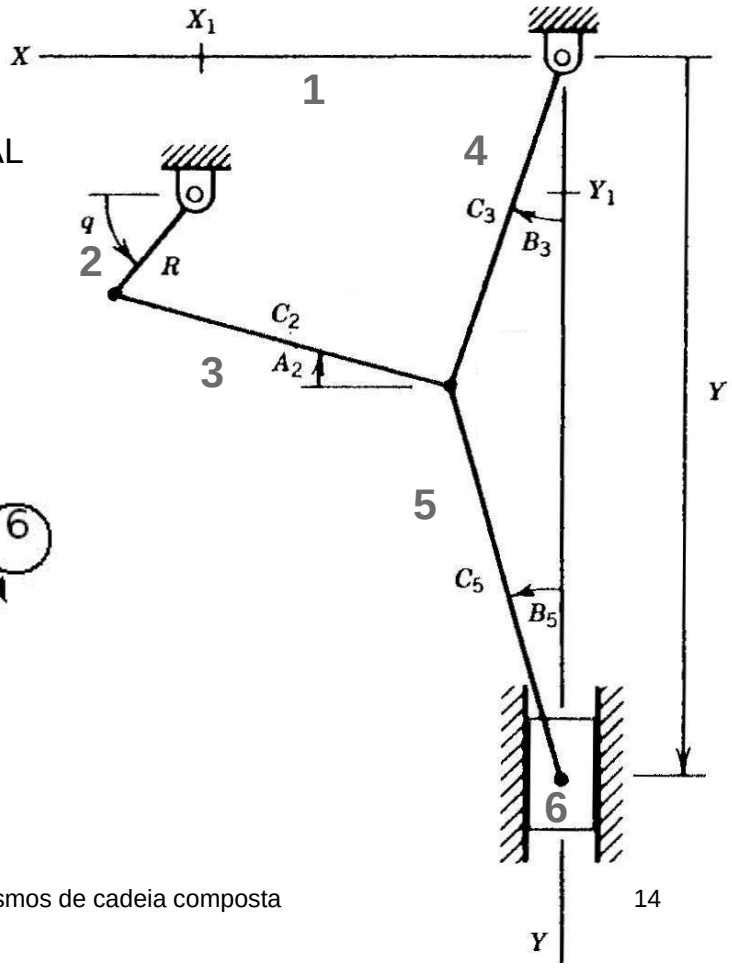


$N := 6 \qquad P_1 := 7 \qquad P_2 := 0$

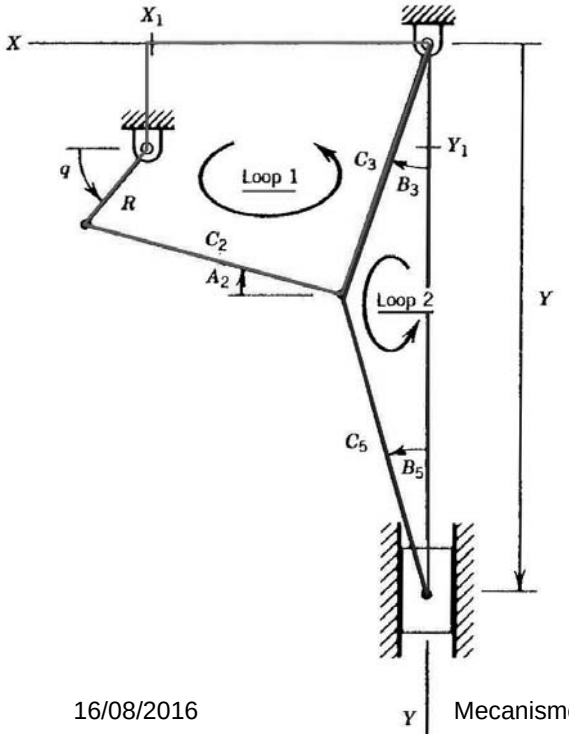
$F := 3\cdot(N - 1) - 2\cdot P_1 - P_2 \qquad F = 1$

2. Decomposição dos pares superiores
3. Definição do sistema GLOBAL de coordenadas
4. Identificação das medidas constantes
5. Definição das variáveis primárias e secundárias



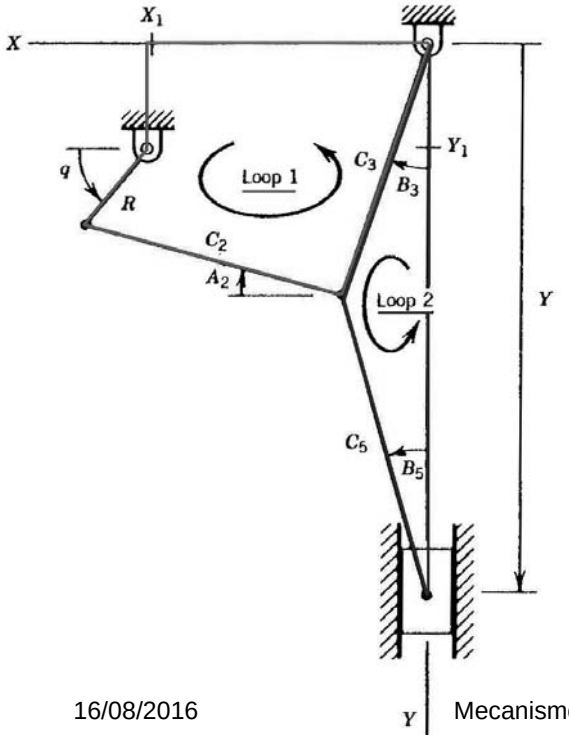


6.Montagem das equações cinemáticas de posição



Identificação dos circuitos

6.Montagem das equações cinemáticas de posição



Cada circuito fornece um par de equações

$$X1 + R\cdot\cos(q) - C2\cdot\cos(A2) - C3\cdot\sin(B3) = 0$$

$$Y1 + R\cdot\sin(q) + C2\cdot\sin(A2) - C3\cdot\cos(B3) = 0$$

$$C3\cdot\sin(B3) - C5\cdot\sin(B5) = 0$$

$$Y - C3\cdot\cos(B3) - C5\cdot\cos(B5) = 0$$

7-Solução do sistema de equações

intervalo de q: $q := 0deg, 1deg .. 360deg$

valores iniciais: $a2 := 20deg$ $b3 := 20deg$

$b5 := 20deg$ $y := C3 + C5$

Aplicar o critério de Grashof caso o acionamento seja feito através de um mecanismo de quatro barras

Given

$X1 + R\cdot\cos(q) - C2\cdot\cos(a2) - C3\cdot\sin(b3) = 0$

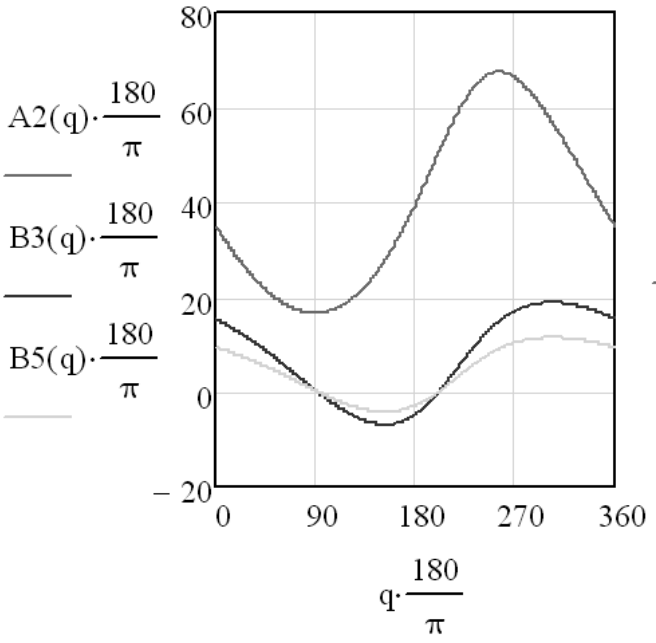
$Y1 + R\cdot\sin(q) + C2\cdot\sin(a2) - C3\cdot\cos(b3) = 0$

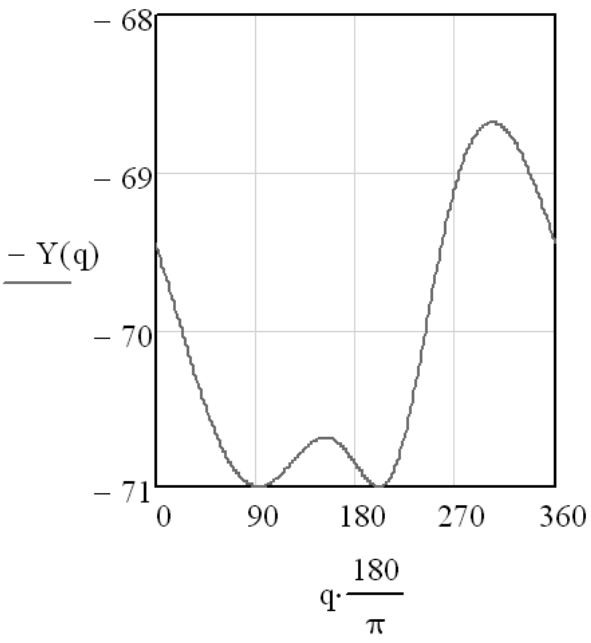
$C3\cdot\sin(b3) - C5\cdot\sin(b5) = 0$

$y - C3\cdot\cos(b3) - C5\cdot\cos(b5) = 0$

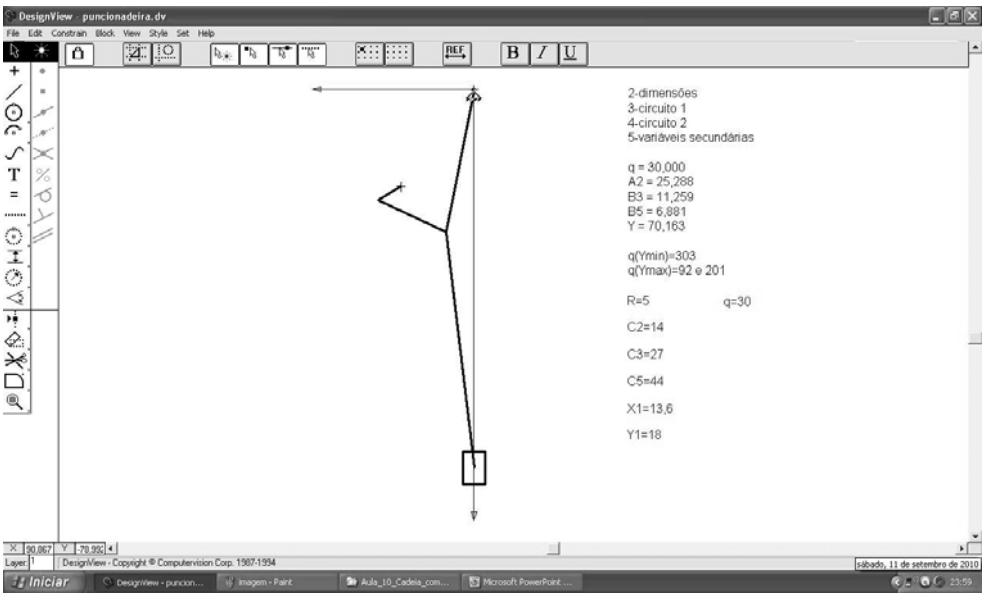
$$\begin{pmatrix} A2(q) \\ B3(q) \\ B5(q) \\ Y(q) \end{pmatrix} := Find(a2, b3, b5, y)$$

7-Solução para um intervalo de valores de q





7-Solução para um intervalo de valores de q



Arquivo Design View: puncionadeira.dv

Equações das velocidades

$$J \cdot \dot{S} + Q \cdot \dot{q} = 0$$

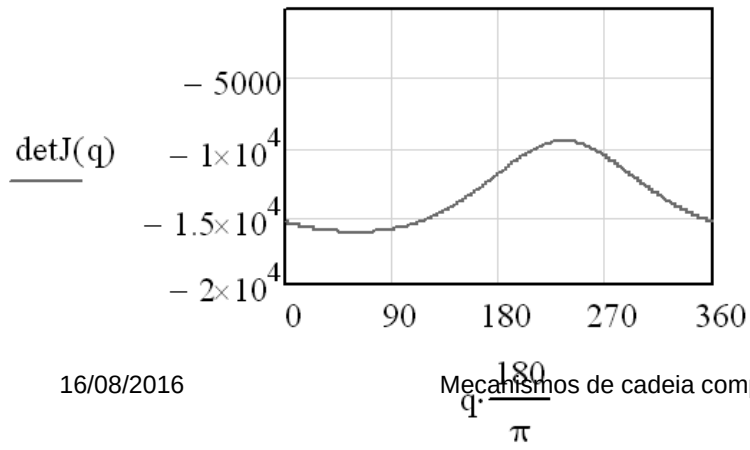
$$J(q) = \begin{pmatrix} C2 \cdot \sin(A2(q)) & -C3 \cdot \cos(B3(q)) & 0 & 0 \\ C2 \cdot \cos(A2(q)) & C3 \cdot \sin(B3(q)) & 0 & 0 \\ 0 & C3 \cdot \cos(B3(q)) & -C5 \cdot \cos(B5(q)) & 0 \\ 0 & C3 \cdot \sin(B3(q)) & C5 \cdot \sin(B5(q)) & 1 \end{pmatrix}$$

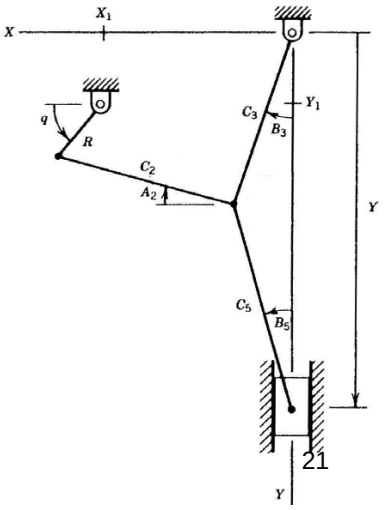
$$Q(q) = \begin{pmatrix} -R \cdot \sin(q) \\ R \cdot \cos(q) \\ 0 \\ 0 \end{pmatrix}$$

Determinante da matriz Jacobiana

$$J(q) := \begin{pmatrix} C2\cdot\sin(A2(q)) & -C3\cdot\cos(B3(q)) & 0 & 0 \\ C2\cdot\cos(A2(q)) & C3\cdot\sin(B3(q)) & 0 & 0 \\ 0 & C3\cdot\cos(B3(q)) & -C5\cdot\cos(B5(q)) & 0 \\ 0 & C3\cdot\sin(B3(q)) & C5\cdot\sin(B5(q)) & 1 \end{pmatrix}$$

$$\det J(q) := -C2\cdot C3\cdot C5\cdot\cos(B5(q))\cdot\cos(A2(q) - B3(q))$$





Solução para as velocidades secundárias

$$\begin{pmatrix} \dot{A}2(q) \\ \dot{B}3(q) \\ \dot{B}5(q) \\ \dot{Y}(q) \end{pmatrix} = -\begin{pmatrix} C2\cdot\sin(A2(q)) & -C3\cdot\cos(B3(q)) & 0 & 0 \\ C2\cdot\cos(A2(q)) & C3\cdot\sin(B3(q)) & 0 & 0 \\ 0 & C3\cdot\cos(B3(q)) & -C5\cdot\cos(B5(q)) & 0 \\ 0 & C3\cdot\sin(B3(q)) & C5\cdot\sin(B5(q)) & 1 \end{pmatrix}^{-1} \cdot \begin{pmatrix} -R\cdot\sin(q) \\ R\cdot\cos(q) \\ 0 \\ 0 \end{pmatrix} \cdot \dot{q}$$

$$\dot{S}(q) = -J(q)^{-1}\cdot Q(q)\cdot\dot{q}$$

$$\boxed{K(q) = -J(q)^{-1}\cdot Q(q)}$$

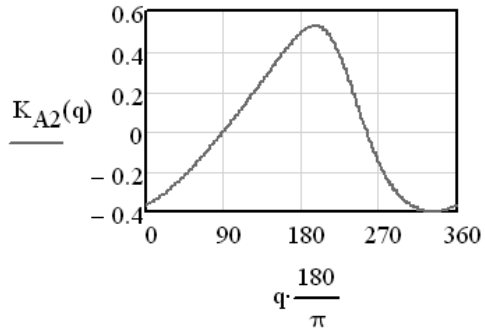
$$\dot{S}(q) = K(q)\cdot\dot{q}$$

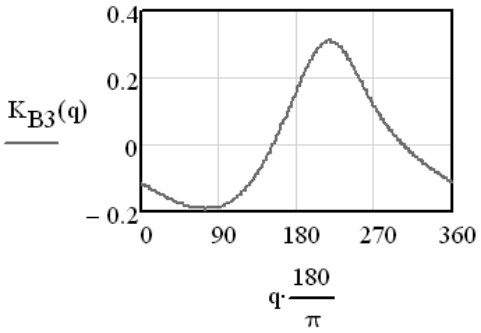
A obtenção algébrica de K começa a ficar mais complicada pelo aumento das dimensões da matriz Jacobiana J e do vetor primário Q

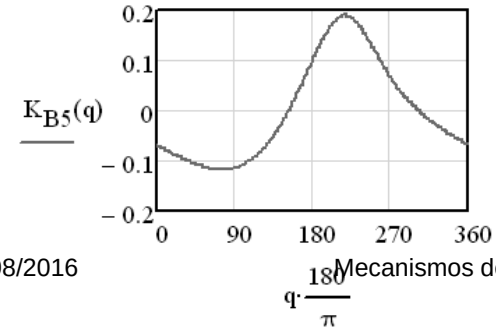
Coeficientes de velocidade

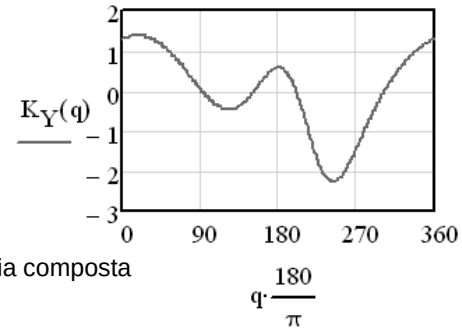
$$K(q) := -J(q)^{-1} \cdot Q(q)$$

$$K_{A2}(q) := K(q)_0 \qquad K_{B3}(q) := K(q)_1 \qquad K_{B5}(q) := K(q)_2 \qquad K_Y(q) := K(q)_3$$









Acelerações secundárias

$$\ddot{S} = K \cdot \ddot{q} + L \cdot \dot{q}^2$$

OK **?**

$$K(q) = -J(q)^{-1} \cdot Q(q)$$

Obtenção das derivadas dos coeficientes de velocidade (L)

$$\dot{J}\cdot\dot{S} + Q\cdot\ddot{q} = 0$$

$$\left.\begin{array}{l} \dot{S} = K\cdot\dot{q} \end{array}\right\} \quad J\cdot K\cdot\ddot{q} = -Q\cdot\dot{q}$$

$$J\cdot K = -Q$$

Derivando em relação a q:

$$\frac{d}{dq}J\cdot K + J\cdot\left(\frac{d}{dq}K\right) = -\frac{d}{dq}Q$$

Sabendo-se que:

$$\frac{d}{dq}K = L$$

$$\frac{d}{dq}J\cdot K + J\cdot L = -\frac{d}{dq}Q$$

$$J\cdot L = -\frac{d}{dq}Q - \frac{d}{dq}J\cdot K$$

$$L = -J^{-1}\cdot\left(\frac{d}{dq}Q + \frac{d}{dq}J\cdot K\right)$$

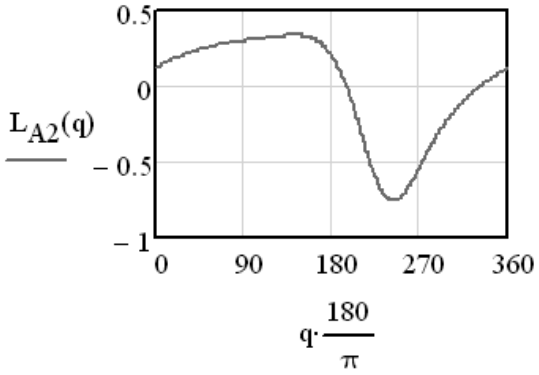
Derivadas dos coeficientes de velocidade

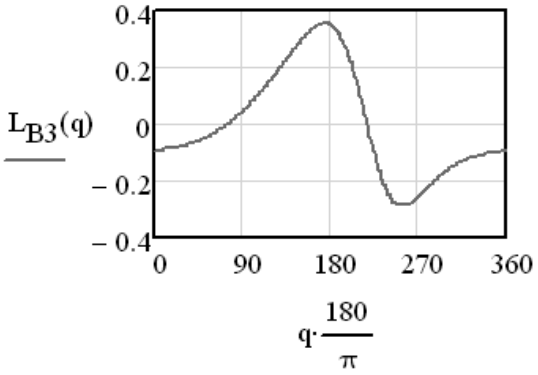
$$L = -J^{-1}\cdot\left(\frac{d}{dq}Q + \frac{d}{dq}J\cdot K\right)$$

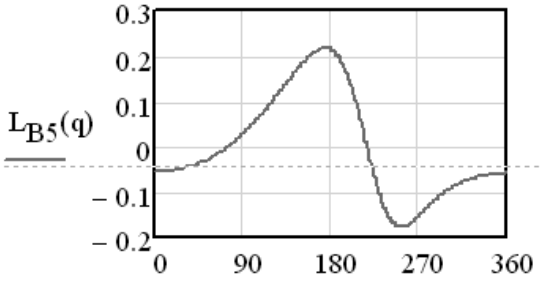
$$\frac{d}{dq}Q = \begin{pmatrix} -R\cdot\cos(q) \\ -R\cdot\sin(q) \\ 0 \\ 0 \end{pmatrix}$$

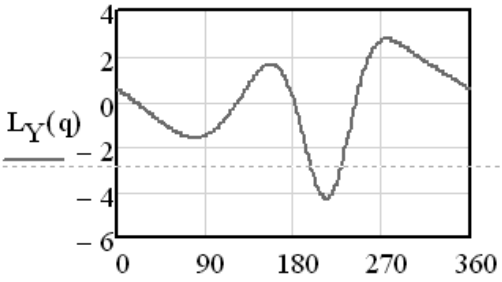
$$\frac{d}{dq}J = \begin{pmatrix} C2\cdot K_{A2}(q)\cdot\cos(A2(q)) & C3\cdot K_{B3}(q)\cdot\sin(B3(q)) & 0 & 0 \\ -C2\cdot K_{A2}(q)\cdot\sin(A2(q)) & C3\cdot K_{B3}(q)\cdot\cos(B3(q)) & 0 & 0 \\ 0 & -C3\cdot K_{B3}(q)\cdot\sin(B3(q)) & C5\cdot K_{B5}(q)\cdot\sin(B5(q)) & 0 \\ 0 & C3\cdot K_{B3}(q)\cdot\cos(B3(q)) & C5\cdot K_{B5}(q)\cdot\cos(B5(q)) & 0 \end{pmatrix}$$

Derivadas dos coeficientes de velocidade



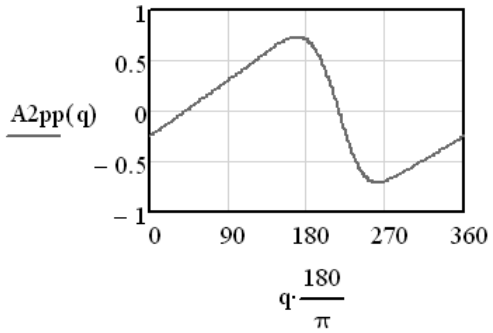


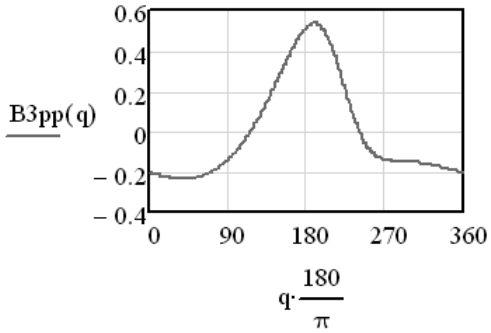


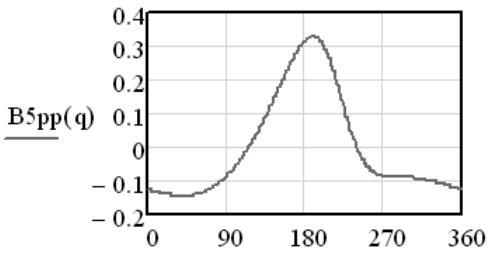


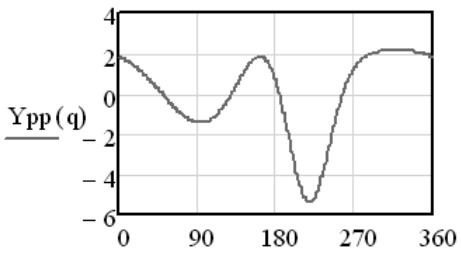
Acelerações secundárias

$$\ddot{S} = K \cdot \ddot{q} + L \cdot \dot{q}^2$$

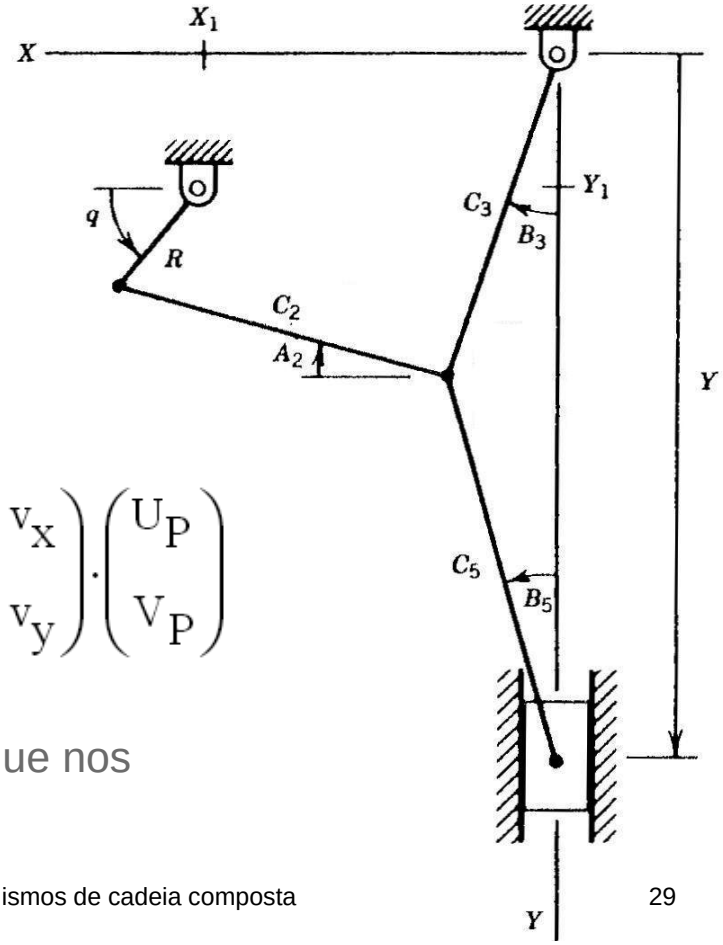








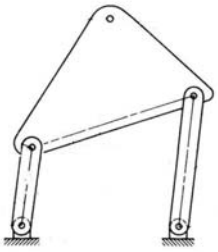
Análise de pontos de interesse

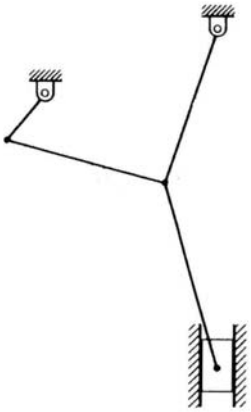


$$\begin{pmatrix} X_P \\ Y_P \end{pmatrix} = \begin{pmatrix} O_x \\ O_y \end{pmatrix} + \begin{pmatrix} u_x & v_x \\ u_y & v_y \end{pmatrix} \cdot \begin{pmatrix} U_P \\ V_P \end{pmatrix}$$

Mesmo procedimento que nos exemplos anteriores.

Comparação





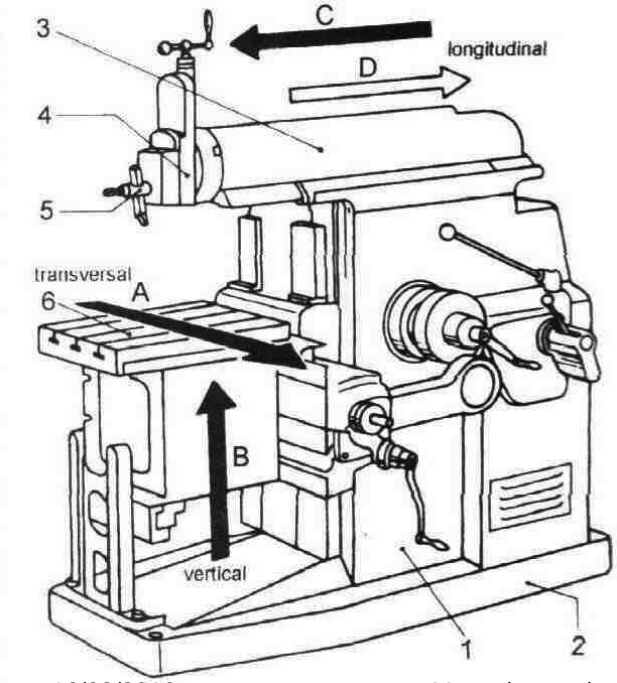
Cadeia simples

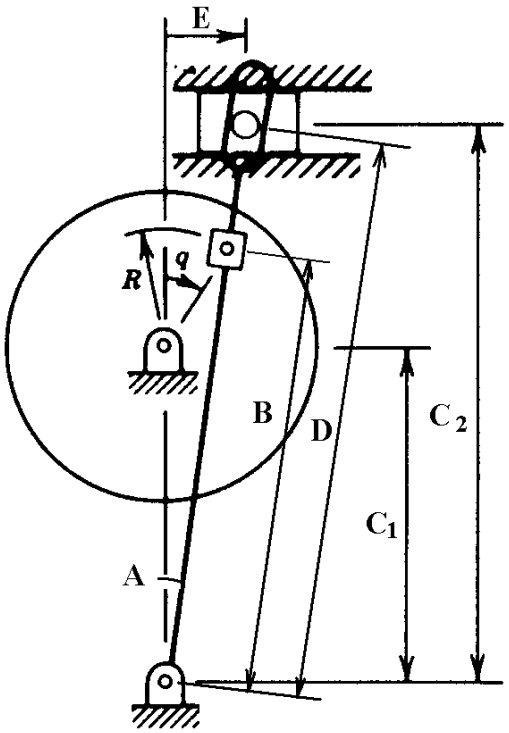
- Duas equações cinemáticas
- Dois coeficientes de velocidade
- Duas derivadas dos coeficientes de velocidade
- Duas variáveis secundárias

Cadeia composta com N circuitos

- $2N$ equações cinemáticas
- $2N$ coeficientes de velocidade (K)
- $2N$ derivadas dos coeficientes de velocidade (L)
- $2N$ variáveis secundárias

Exercício: plaina





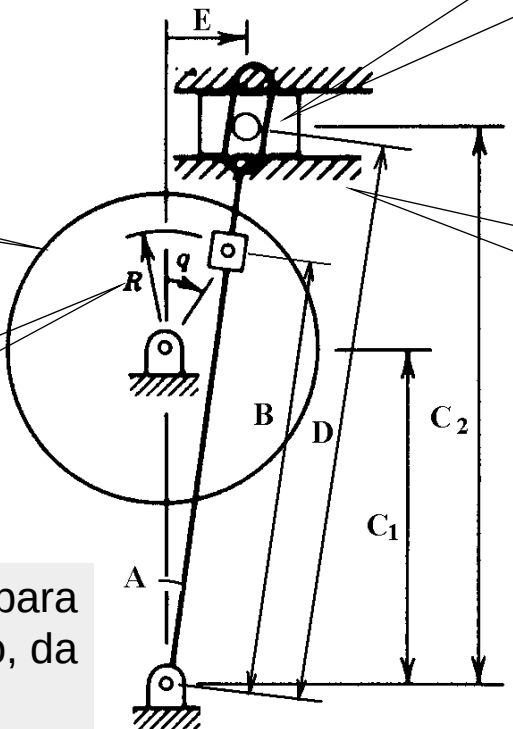
Exercício: plaina

Torpedo (porta-ferramenta)

Volante (acionamento)

Base da máquina (elo fixo)

Regulagem do deslocamento



$C_1 := 0.4\text{m}$

$C_2 := 0.75\text{m}$

$R := 0.085\text{m}$

Obter as equações para o cálculo da posição, da velocidade e da aceleração de cada elo.