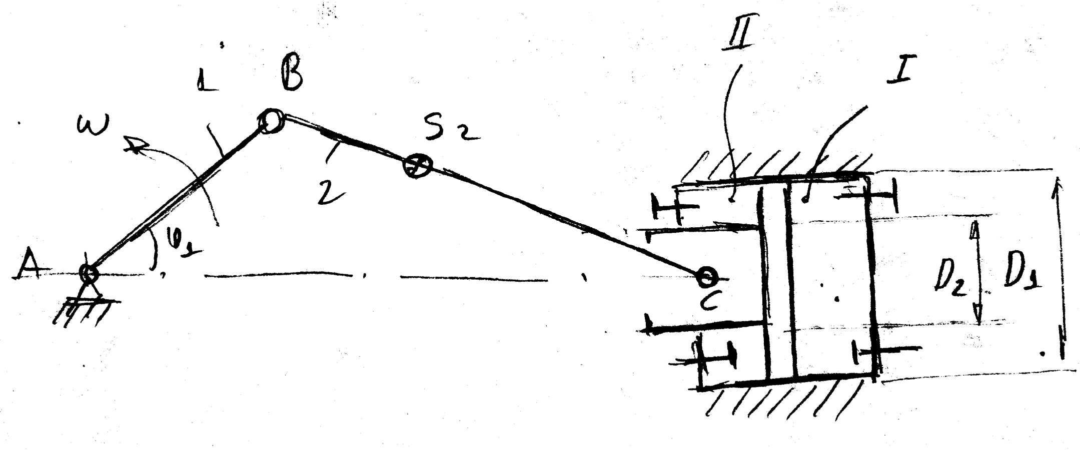


Calcular el momento de inercia de la volante que debe ser instalado en el eslabón 1 para asegurar un $\delta = 0{,}0125$

Datos: $l_{AB} = 0{,}05\ m$; $l_{BC} = 0{,}25\ m$; $l_{BS_2} = 0{,}10\ m$

$D_1 = 0{,}13\ m$; $D_2 = 0{,}11\ m$

$m_2 = 1{,}8\ kg$; $m_3\ 2{,}2\ kg$

$J_{S2} = 0{,}025\ kgm^2$

$J_O = 0{,}07\ kgm^2$ — Momento de inercia de la manivela junto con las masas rotatorias del motor elect.

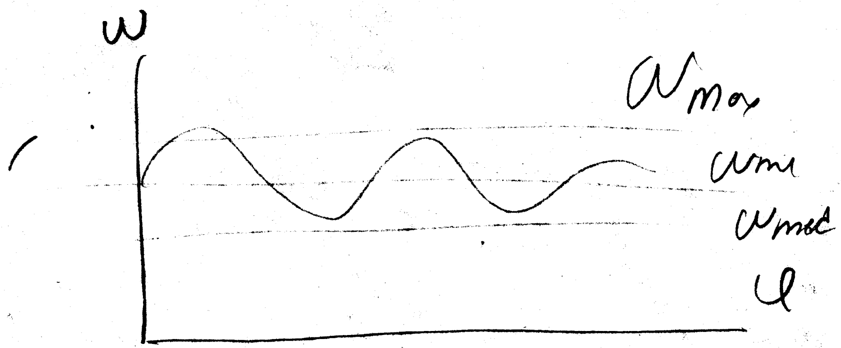
Presión en el cilindro dada por un diagrama indicado

$$\begin{cases} P_{I\,max} = 2{,}25 \cdot 10^5\ Pa \\ P_{II\,max} = 6{,}75 \cdot 10^5\ Pa \end{cases}$$

M_m - constante y debe ser calculado

$n_{1mid} = 800\ rpm$

MATLAB\prepa2009\EnsaWitten.m

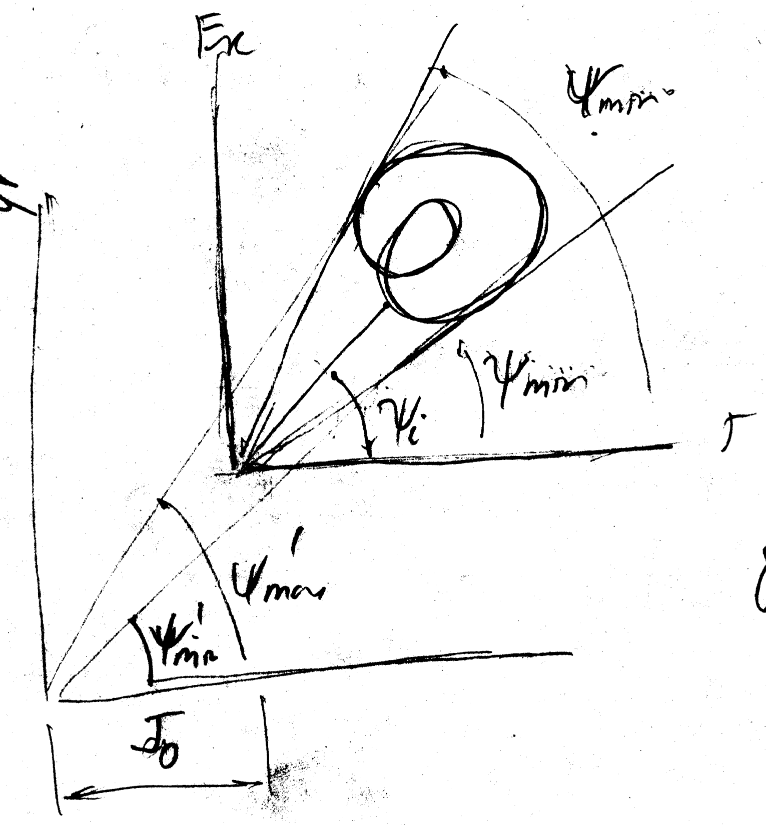


$$\omega_{med} = \frac{\omega_{max} + \omega_{min}}{2}$$

$$\delta = \frac{\omega_{max} - \omega_{min}}{\omega_{med}}$$

$$\omega_i = \sqrt{2 \tan \psi_i}$$

$$\boxed{\begin{aligned} \tan \psi_{max} &= \frac{1}{2} \omega_{med}^2 (1+\delta) \\ \tan \psi_{min} &= \frac{1}{2} \omega_{med}^2 (1-\delta) \end{aligned}}$$

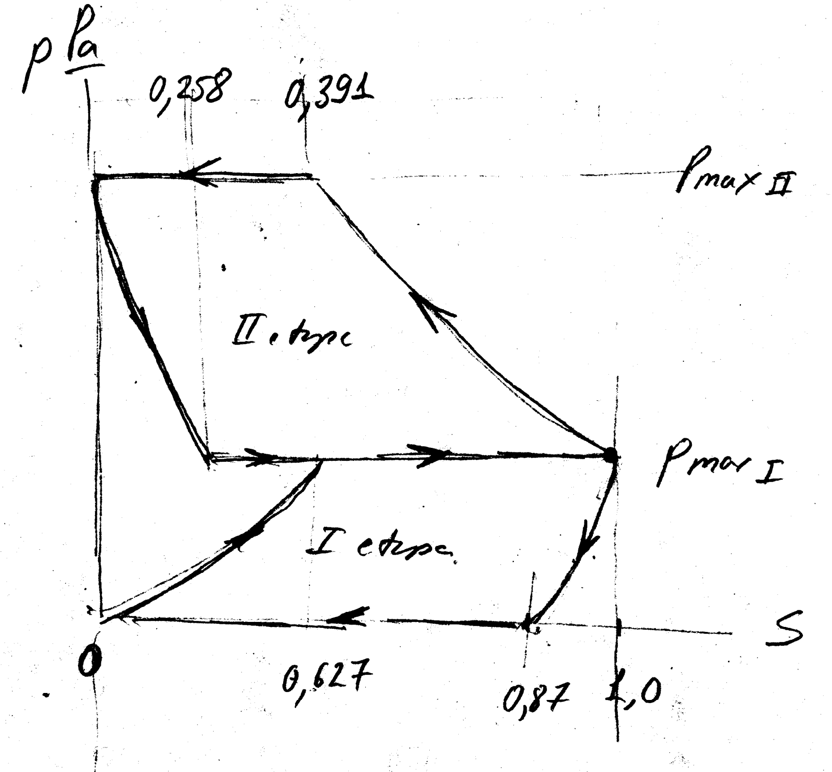


δ'

$$\tan \psi'_{max} = \frac{1}{2} \omega_{med}^2 (1+\delta')$$

$$\tan \psi'_{min} = \frac{1}{2} \omega_{med}^2 (1-\delta')$$

(2)



$$P_I = \begin{cases} eq1 \rightarrow S\ (1{,}0-0{,}87)\ y\ \varphi_1\ (0-\pi) \\ 0 \rightarrow S\ (0{,}87-0)\ y\ \varphi_1\ (0-\pi) \\ eq2 \rightarrow S\ (0-0{,}627)\ y\ \varphi_1\ (\pi-2\pi) \\ 2{,}25\cdot10^5\ S\ (0{,}627-1{,}0)\ y\ \varphi_1\ (\pi-2\pi) \end{cases}$$

$$eq1 = 0{,}7226\cdot10^7 S^2 - 1{,}1782\cdot10^7 S + 0{,}4781\cdot10^7;$$

$$eq2 = 1{,}6940\cdot10^5 S^2 + 2{,}5264\cdot10^5 S;$$

$$
p_{II} = \begin{cases} eq3 \to s\,(1{,}0 - 0{,}391) \text{ y } \varphi_1\,(0 - \pi) \\ 6{,}75 \cdot 10^5 \to s\,(0{,}391 - 0) \text{ y } \varphi_1\,(0 - \pi) \\ eq4 - s\,(0 - 0{,}258) \text{ y } \varphi_1\,(\pi - 2\pi) \\ 2{,}25 \cdot 10^5 \; s\,(0{,}258 - 1{,}0) \text{ y } \varphi_1\,(\pi - 2\pi) \end{cases}
$$

$eq3 = 0{,}3955 \cdot 10^6 s^2 - 1{,}2890 \cdot 10^6 s + 1{,}1185 \cdot 10^6$;

$eq4 = 2{,}7547 \cdot 10^6 s^2 - 2{,}4549 \cdot 10^6 s + 0{,}6750 \cdot 10^6$;

---

(4)

```
%Cálculo de la masa de la Volante por el método de Wittenbauer
%Datos de entrada

clc,clear all, close all
l1=0.05; l2=0.25; lbs2=0.10;
D1=0.13; D2=0.11;
J0=0.07;
J2=0.025; m2=1.8; m3=2.2;
omegamed=(pi*800)/30;
deltaprim=0.0125;

Ndatos=3600;
```

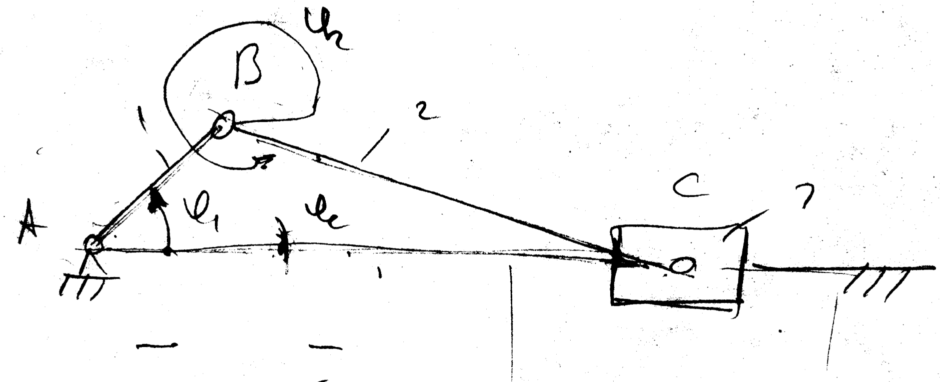
poner 36 para controlar valores durante el desarrollo

```
fi1=linspace (0,360,Ndatos+1)
fi1=fi1/180*pi
carrera=l1*2;
pms=l1+l2
pmi=l2-l1
```

pasando a radianes

(1)

Cinematica.



$$\bar{r}_1 + \bar{r}_2 = \bar{r}_c$$

$$\begin{cases} l_1 \cos\varphi_1 + l_2 \cos\varphi_2 - l_c \cos\varphi_c = 0 \\ l_1 \sin\varphi_1 + l_2 \sin\varphi_2 - l_c \sin\varphi_c = 0 \end{cases}$$

$$\begin{cases} l_1 \cos\varphi_1 + l_2 \cos\varphi_2 - x_c = 0 \\ l_1 \sin\varphi_1 + l_2 \sin\varphi_2 = 0 \end{cases}$$

$$\boxed{x_c = l_1 \cos\varphi_1 + \sqrt{l_2^2 - l_1^2 \sin^2\varphi_1}}$$

$$\varphi_2 = -\arcsin\left(l_1 \sin\varphi_1 / l_2\right)$$

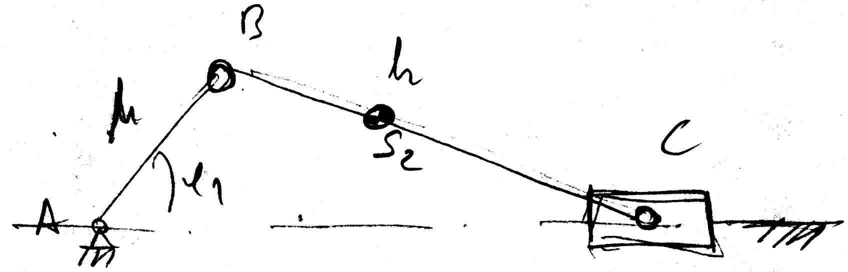
```
%Mecanismo R RRP
%POSICION
clc, clear all

syms l1 fi1 l2 fi2 xc
eqpos=[l1*cos(fi1)+l2*cos(fi2)-xc,l1*sin(fi1)+l2*sin(fi2)]
S=solve(eqpos(1),eqpos(2),fi2,xc)
simple(S.fi2)
simple(S.xc)

%VELOCIDAD

clear all
syms l1 fi1 l2 fi2 xc
eqpos=[l1*cos(fi1)+l2*cos(fi2)-xc,l1*sin(fi1)+l2*sin(fi2)]
varpos=[fi1,fi2,xc]
jvelo=jacobian(eqpos,varpos)

syms omega1 omega2 vxc
varpospunto=[omega1; omega2; vxc]
eqvelo=jvelo*varpospunto
omegas=solve(eqvelo(1),eqvelo(2),omega2,vxc)
simple(omegas.omega2)
simple(omegas.vxc)
```



$$\bar{\Phi}(\bar{q}) = 0 \; : \; \begin{cases} l_1 \cos\varphi_1 + l_2 \cos\varphi_2 - x_C = 0 \\ l_1 \sin\varphi_1 + l_2 \sin\varphi_2 = 0 \end{cases}$$

$$\bar{q} = \{\varphi_1, \varphi_2, x_C\} \leftarrow \text{vector de coordonate}$$

Vitezele

$$\bar{\Phi}_{(q)}(\bar{q}) \cdot \bar{\dot{q}}^T = 0 \qquad \dot{q} = \begin{Bmatrix} \omega_1 \\ \omega_2 \\ v_{xC} \end{Bmatrix}$$

Vit. punct B

$$\begin{cases} x_B = x_A + l_1 \cos\varphi_1 \\ y_B = y_A + l_1 \sin\varphi_1 \end{cases}$$

$$\begin{cases} v_{xB} = v_{xA} - l_1 \sin\varphi_1 \, \omega_1 \\ v_{yB} = v_{yA} + l_1 \cos\varphi_1 \, \omega_1 \end{cases}$$

Symbolic R_RRP.m

(8)

```
%Cinemática del mecanismo

omega1=1; %sólo para la reducción
for N=1:Ndatos+1
xc(N)=l1*cos(fi1(N))+(l2^2-l1^2*sin(fi1(N))^2)^(1/2);
sc(N)=(xc(N)-pmi)/carrera;
fi2(N)=-asin(l1*sin(fi1(N))/l2);
omega2(N)=-l1*cos(fi1(N))*omega1/l2/cos(fi2(N));
vxc(N)=-l1*omega1*sin(fi1(N)-fi2(N))/cos(fi2(N));

vxb(N)=-l1*sin(fi1(N))*omega1;
vyb(N)= l1*cos(fi1(N))*omega1;
vxs2(N)=vxb(N)-lbs2*sin(fi2(N))*omega2(N);
vys2(N)=vyb(N)+lbs2*cos(fi2(N))*omega2(N);
vs2(N)=sqrt(vxs2(N)^2+vys2(N)^2);
end
```

control:

vs2(17) → 0,0323

$$J_{esl} = J_2 \left(\frac{\omega_2}{\omega_1}\right)^2 + m_2 \left(\frac{V_{S2}}{\omega_1}\right)^2 + m_3 \left(\frac{V_C}{\omega_1}\right)^2;$$

9

$$\begin{cases} x_{S2} = x_B + l_{BS2} \cos \varphi_2 \\ y_{S2} = y_B + l_{BS2} \sin \varphi_2 \end{cases}$$

$$V_{xS2} = V_{xB} - l_{BS2} \sin \varphi_2 \, \omega_2$$

$$V_{yS2} = V_{yB} + l_{BS2} \cos \varphi_2 \, \omega_2$$

$$V_{S2} = \sqrt{v_{xS2}^2 + v_{yS2}^2}$$

```
%Diagramas indicados

for N=1:Ndatos+1
    if and(sc(N)<=1.0 && sc(N)>=0.87   , fil(N)>=0 && fil(N)<=pi)==1
         pI(N)=0.7226e7*sc(N)^2-1.1782e7*sc(N)+0.4781e7;
    elseif and(sc(N)<0.87 && sc(N)>0   , fil(N)>0 && fil(N)<pi)==1
        pI(N)=0;
    elseif and(sc(N)>=0 && sc(N)<=0.627 , fil(N)>=pi && fil(N)<=2*pi)==1
        pI(N)=1.6940e5*sc(N)^2+2.5264e5*sc(N);
    else
         pI(N)=2.25e5;
    end
end

plot(sc,pI),title('Diagrama Indicado del compresor'),xlabel ('s'),ylabel
                  ('presión Pa')

 for N=1:Ndatos+1
    if and(sc(N)<=1.0 && sc(N)>=0.391    , fil(N)>=0 && fil(N)<=pi)==1
           pII(N)=0.3955e6*sc(N)^2-1.2890e6*sc(N)+1.1185e6;
      elseif and(sc(N)<0.391 && sc(N)>0   , fil(N)>0 && fil(N)<pi)==1
           pII(N)=6.75e5;
      elseif and(sc(N)>=0 && sc(N)<=0.258 , fil(N)>=pi &&
fil(N)<=2*pi)==1
            pII(N)=2.7547e6*sc(N)^2-2.4549e6*sc(N)+0.6750e6;
      else
         pII(N)=2.25e5;
    end
 end

hold on
 plot(sc,pII);grid
```

controlar max valores, es decir comparar con el dibujo.

```
%Fuerzas sobre el cilindro
FI=pi*D1^2/4*pI;
FII=pi*(D1^2-D2^2)/4*pII;
Fp=FII-FI;
```

$$F_I = \frac{\pi D_1^2}{4} \cdot p_I$$

$$F_{II} = \frac{\pi (D_1^2 - D_2^2)}{4} \cdot p_{II}$$

$$F_p = F_{II} - F_I$$

Reducción de las fuerzas

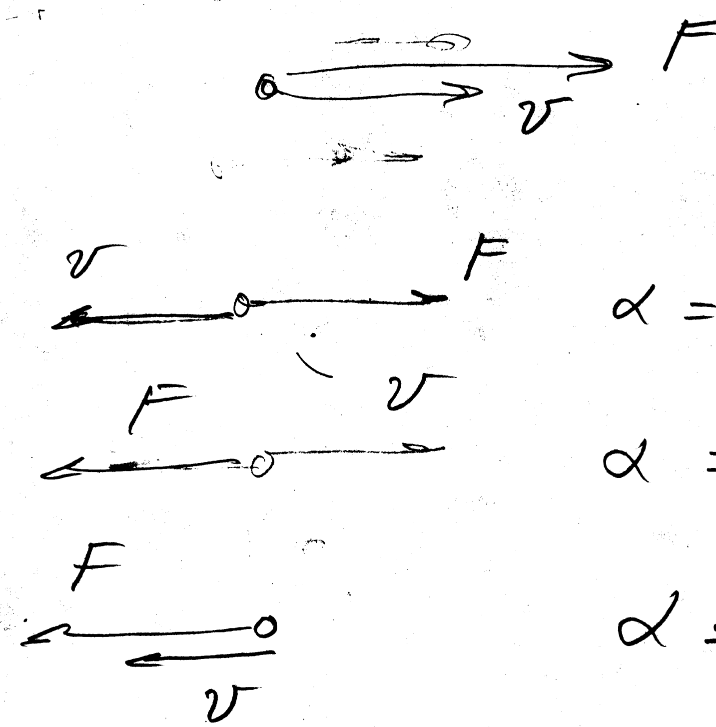
$$M_{red} = \sum F_i \frac{v_i \cos\alpha_i}{\omega} + \sum M_i \frac{\omega_i}{\omega}$$

asumimos $\omega = 1 \ \mathrm{rad/s}$

$$\boxed{M_{red} = |F_3|\,|v_{C(\omega=1)}|\,\cos\alpha}$$

?

F	v	α	$\cos\alpha$
+	+	0	1
+	−	180°	−1
−	+	180°	−1
−	−	0°	1

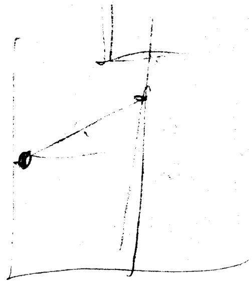


$\alpha = 0°$

$\alpha = 180°$

$\alpha = 180°$

$\alpha = 0°$



$$\cos\alpha = \mathrm{sign}\, F_p \cdot \mathrm{sig}\, V_{xc}$$

```
%Reducción del Momento
for N=1:Ndatos+1
    cosenoalfa=(sign(Fp(N))*sign(vxc(N)));
    Mc(N)=-abs(Fp(N))*abs(vxc(N))*cosenoalfa;%ojo con el "menos" y con
                                              los valores absolutos
end
Mc

figure
plot(fil,Fp),title('Fuerza en el cilindro'),xlabel ('fil rad'),ylabel
                                                  ('fuerza N')
grid
figure
plot(fil,Mc),title('Momento reducido - Momento motor'),xlabel ('fil
                            rad'),ylabel ('Momento N.m')
grid
```

!!

Control :

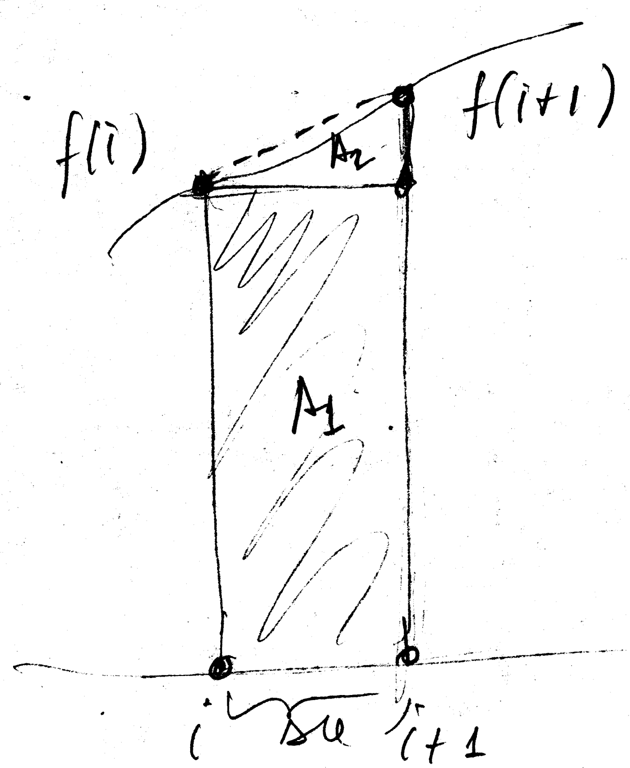
$Mc(17) = 35,3191$

$$h = \frac{b-a}{2}$$

regla de Simpson

$$\int_a^b f(x)\,dx \approx \frac{h}{3}\left[f(a) + 4f\left(\frac{a+b}{2}\right) + f(b)\right]$$

Regla Trapezoidal



$$A = A_1 + A_2$$

$$A_1 = \underbrace{[(i+1) - i]}_{\Delta\varphi} \cdot f(i)$$

$$A_2 = \frac{[(i+1) - i] \cdot [f(i+1) - f(i)]}{2}$$

$$A = \Delta\varphi\, Mc(N) + \frac{1}{2}\Delta\varphi\,(Mc(N+1) - Mc(N))$$

```
%Cálculo del Momento Motor
%Integración total del momento por trapecios

deltafi=fi1(2)-fi1(1);
Area=0;
for N=1:Ndatos
   A(N)=(deltafi*Mc(N))+0.5*(deltafi*(Mc(N+1)-Mc(N)));
   Area=Area+A(N);
end

Mm=Area/(2*pi)
Mmot=ones(1,Ndatos+1)*Mm;
hold on
plot (fi1,Mmot,'r')
```

$\to \Delta\varphi$

$$\boxed{Mm \times 2\pi = Area}$$

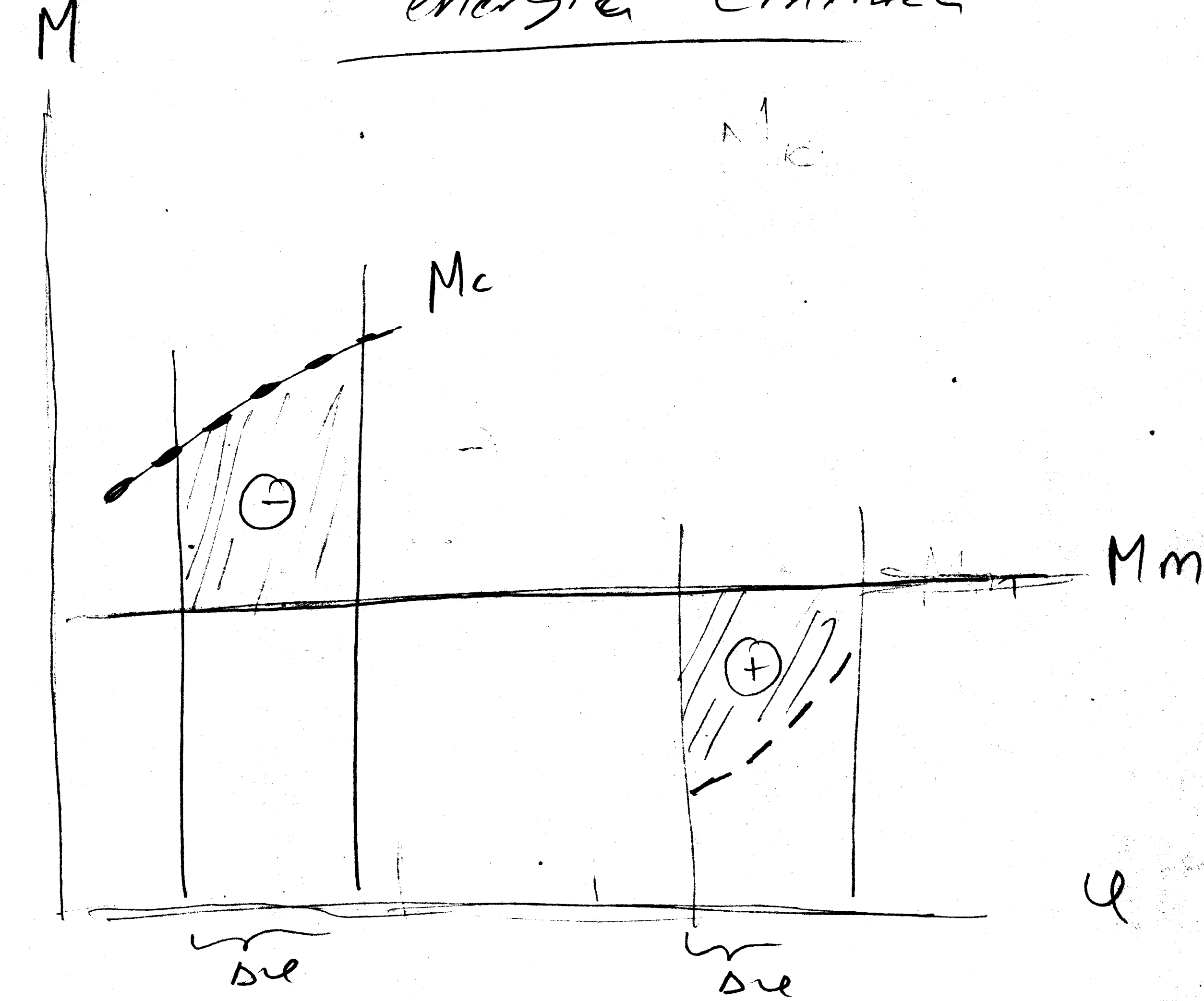
bajo Momento resistivo

$$Mm = \frac{Area}{2\pi}$$

Área bajo momento motor constante

Control $Mm = 43{,}5630$ N.m

Variación de la energía cinética



$$\Delta E_K = A_{(Mm)} - A_{(Mc)}$$

$$\Delta E_K = \left(\Delta\varphi \cdot Mm(N)\right) - \Delta\varphi\left(Mc(N) + \frac{1}{2}\left(Mc(N+1) - Mc(N)\right)\right)$$

```
%Cálculo de la variación de la energía cinética
%Integración por trapecios

EK(1)=0;
for N=2:Ndatos
   DeltaEK(N)=(deltafi*Mmot(N))-deltafi*(Mc(N)+0.5*(Mc(N+1)-Mc(N)));
   EK(N)=EK(N-1)+DeltaEK(N);
end
EK(Ndatos+1)=EK(1);
EK;
figure
plot(fi1,EK),title('Incrementos de Energía Cinética'),xlabel ('fi1
                         rad'),ylabel ('Energía J')
grid
```

Correcto EK(17) = -59,8543

$$J_{esl} = J_2\left(\frac{\omega_2}{\omega_1}\right)^2 + m_2\left(\frac{v_{s2}}{\omega_1}\right)^2 + m_3\left(\frac{v_c}{\omega_1}\right)^2 ;$$

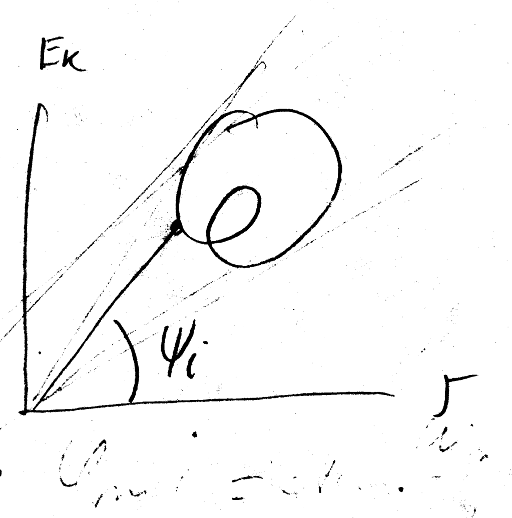
$\omega_1 = 1$!!

```
%Reducción del Momento de inercia de los eslabones sin incluir manivela
for N=1:Ndatos+1
   Jeslab(N)=J2*omega2(N)^2+m2*vs2(N)^2+m3*vxc(N)^2;
end
figure
plot(fi1,Jeslab),title('Momento de inercia reducido'),xlabel ('fi1
                       rad'),ylabel ('Momento Inercia kg.m^2')
grid
```

$J_{eslab}(17) = 0{,}0032\ kg \cdot m^2$

```
%Diagrama de Wittenbauer
figure
plot(Jeslab,EK),title('Diagrama de Wittenbauer'),xlabel ('Momento Inercia
                       kg.m^2'),ylabel ('Energía J')
grid
```

$$\omega_i = \sqrt{2 \tan \psi_i}$$



$$\tan \psi'_{max} = \frac{1}{2}\, \omega^2_{med} (1 + \delta')$$

$$\tan \psi'_{min} = \frac{1}{2}\, \omega^2_{med} (1 - \delta')$$

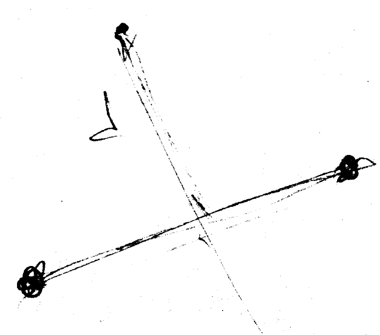
$$\delta' = 0{,}0125$$

$$(0{,}008292 \,;\, -26{,}03)$$

$\underbrace{y = mx + b}$

$p\ [m \quad b]$

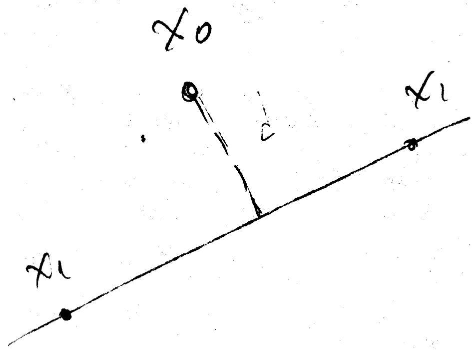
$y\ [y_1 \quad y_2]$



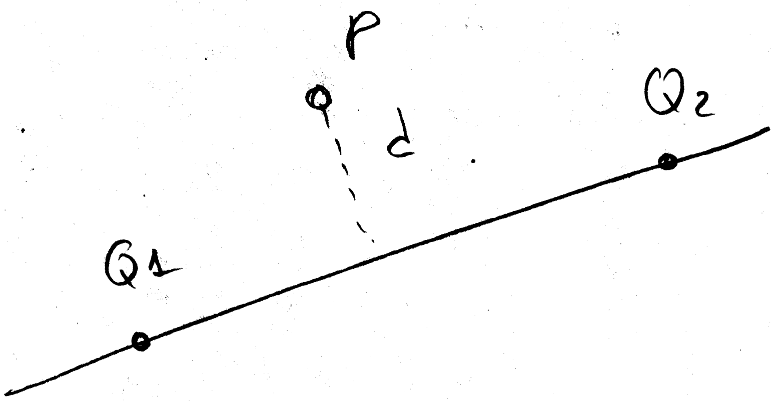
Cómo graficar una recta en matlab

$$y = mx + b$$

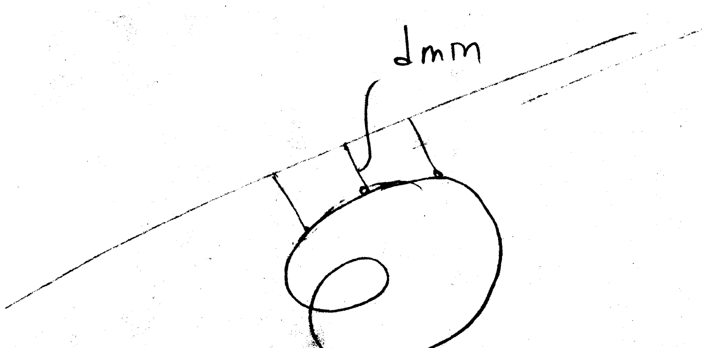
```
p = [m   b]        ← polinomio
x = [x1   x2]      ← intervalo
y = polyval (p, x) ← evaluación
plot (x, y)        ← graficación
```



$$d = \frac{|(x_2 - x_1) \times (x_1 - x_0)|}{|x_2 - x_1|}$$




```
d= abs(det([Q2-Q1 ; P-Q1]))/norm(Q2-Q1);
```



Trazo de una recta por un punto y con pendiente

(22)

$$y - y_1 = m(x - x_1)$$

$$y = m(x - x_1) + y_1$$

$$y = \underbrace{m}_{\tan\gamma'_{max}} x \underbrace{- m x_1 + y_1}_{b_2}$$

$$x_1 = J_{eslab}(Nmm)$$

$$y_1 = EK(Nmm)$$

```
%%%%%%%%%%%%%%%% determinacion de las tangentes max min

format long
tanksimaxprim=(1/2*omegamed^2*(1+deltaprim))
tanksiminprim=(1/2*omegamed^2*(1-deltaprim))

ksimaxprimgrad=(atan(tanksimaxprim))*180/pi
ksiminprimgrad=(atan(tanksiminprim))*180/pi
format

p=[tanksimaxprim 20]; %recta de pendiente "tanksimaxprim" y desplazada en
                        20 unidades
xksimax =[2e-3 11e-3];
yksimax =polyval (p,xksimax);
hold on
plot (xksimax,yksimax,'k')

dmin=1e6          valor grande arbitrario
 for N=1:Ndatos+1
     P=[Jeslab(N) EK(N)];
    Q1= [xksimax(1) yksimax(1)];
    Q2= [xksimax(2) yksimax(2)];
    d(N)= abs(det([Q2-Q1;P-Q1]))/norm(Q2-Q1);
    if d(N)<dmin
      dmin=d(N);
      Nmin=N;
    end
 end

b2=-tanksimaxprim*Jeslab(Nmin)+EK(Nmin)
p2=[tanksimaxprim b2]; %recta tangente a Wittenbauer con pendiente
                              tanksimaxprim

yksimax =polyval (p2,xksimax);

plot (xksimax,yksimax,'r')
plot ( Jeslab(Nmin),EK(Nmin),'*r')
```

```
%%%%%%%%%%%%%%%%%%
p=[tanksiminprim -80]; %recta de pendiente "tanksiminprim" y desplazada
                            en -80 unidades
xksimin =[2e-3 11e-3];
yksimin =polyval (p,xksimax);
plot (xksimin,yksimin,'k')

dmin=1e6
 for N=1:Ndatos+1
     P=[Jeslab(N) EK(N)];
    Q1= [xksimin(1) yksimin(1)];
    Q2= [xksimin(2) yksimin(2)];
    d(N)= abs(det([Q2-Q1;P-Q1]))/norm(Q2-Q1);
    if d(N)<dmin
      dmin=d(N);
      Nmin=N;
    end
 end

b3=-tanksiminprim*Jeslab(Nmin)+EK(Nmin)
p3=[tanksiminprim b3]; %recta tangente a Wittenbauer con pendiente
                                                   tanksiminprim

yksimin =polyval (p3,xksimin);

plot (xksimin,yksimin,'r')
plot (Jeslab(Nmin),EK(Nmin),'*r')
```

$$\begin{cases} p2 = [\ \overset{m_2}{m_{\psi'_{max}}} \quad b_2\ ] \\ p3 = [\ \overset{m_3}{m_{\psi'_{min}}} \quad b_3\ ] \end{cases}$$

Solución de un sistema de ecuaciones lineales dados los polinomios

$$\begin{cases} y = m_2 x + b_2 \\ y = m_3 x + b_3 \end{cases}$$

$$\begin{cases} m_2 x - y = -b_2 \\ m_2 x - y = -b_3 \end{cases}$$

$$A = \begin{vmatrix} m_2 & -1 \\ m_2 & -1 \end{vmatrix}$$

$$B = \begin{bmatrix} -b_2 \\ -b_3 \end{bmatrix}$$

$$C = A \backslash B \quad \begin{cases} C(1) \rightarrow J \\ C(2) - EK \end{cases}$$

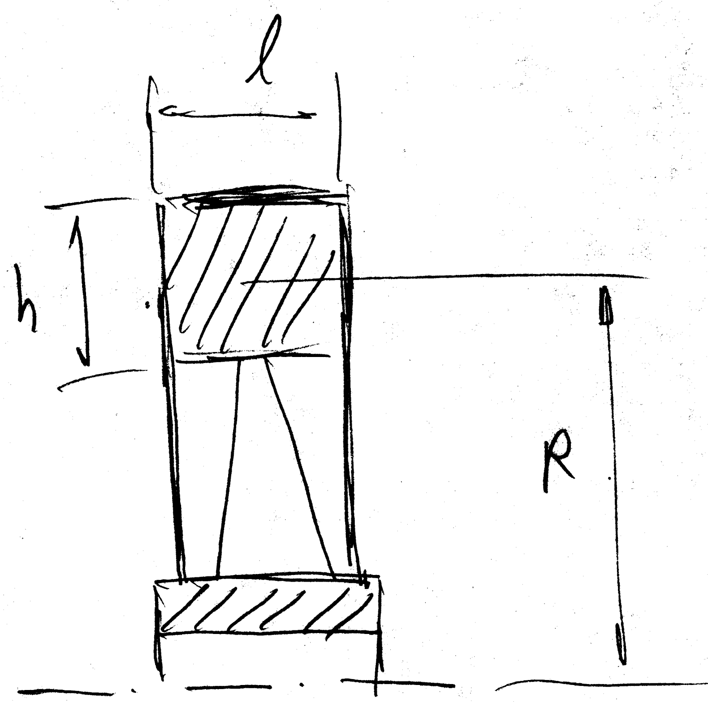
```
%solución del sistema de ecuaciones lineales
%p2=[tanksimaxprim b2];
%p3=[tanksiminprim b3];

format long
A=[tanksimaxprim -1;tanksiminprim -1]
B=[-b2;-b3]
c=A\B
format

%Magnitud del momento de inercia de la volante
Jvol=-c(1)-J0
```

$Jvol = 0{,}8283\ kg\,m^2$ ← para 3600 dctn

$R = 0{,}0313\ m$



$$J = 4\pi \rho l h R$$

$$l = \sim 0,3\,R$$
$$h = \sim 0,3\,R$$

$$J = 4\pi\rho\,(0,3R)(0,3R)\,R$$

$$\rho = 7,8 \cdot 10^3\ kg/m^3$$

$$J = 8,8216\ R^3$$

$$R = \sqrt[3]{\frac{J}{8,8216}}$$