Facultad de Ingenieria
UNLP

ANÁLISIS DINÁMICO AIRBUS A320

Sistemas Dinamicos - Modulo 1 - 2025

POR:
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TABLA DE CONTENIDO

A1

DINAMICA NATURAL DE UN CUERPO RIGIDO

MODELO LINEAL

$$\dot{\boldsymbol{x}} = \boldsymbol{f}(\boldsymbol{x}, \boldsymbol{u}, t)$$

$$\dot{\boldsymbol{x}} = \boldsymbol{f}(\boldsymbol{x}, \boldsymbol{u}) \approx \boldsymbol{f}(\bar{\boldsymbol{x}}, \bar{\boldsymbol{u}}) + \left.\frac{\partial \boldsymbol{f}}{\partial \boldsymbol{x}}\right|_{\bar{\boldsymbol{x}}, \bar{\boldsymbol{u}}} (\boldsymbol{x} - \bar{\boldsymbol{x}}) + \left.\frac{\partial \boldsymbol{f}}{\partial \boldsymbol{u}}\right|_{\bar{\boldsymbol{x}}, \bar{\boldsymbol{u}}} (\boldsymbol{u} - \bar{\boldsymbol{u}}) + \cdots$$

$$\mathbf{A} = \left.\frac{\partial \boldsymbol{f}}{\partial \boldsymbol{x}}\right|_{\bar{\boldsymbol{x}}, \bar{\boldsymbol{u}}}, \quad \Delta \boldsymbol{x} = \boldsymbol{x} - \bar{\boldsymbol{x}}$$

$$\mathbf{B} = \left.\frac{\partial \boldsymbol{f}}{\partial \boldsymbol{u}}\right|_{\bar{\boldsymbol{x}}, \bar{\boldsymbol{u}}}, \quad \Delta \boldsymbol{u} = \boldsymbol{u} - \bar{\boldsymbol{u}}$$

$$\longrightarrow \quad \dot{\boldsymbol{x}} = \mathbf{A}\boldsymbol{x} + \mathbf{B}\boldsymbol{u} \quad \longrightarrow \quad \mathbf{A}\boldsymbol{v}_j = \lambda_j \boldsymbol{v}_j$$

λ_j ⟶ evolucion temporal de la amplitud de x

$\boldsymbol{v}_j$ ⟶ direccion en el espacio de estados

COORDENADAS MODALES

$$\boldsymbol{\Lambda} = [\boldsymbol{v}_1 \boldsymbol{v}_2 \cdots \boldsymbol{v}_n]$$

$$\bar{\mathbf{A}} = \boldsymbol{\Lambda}^{-1}\mathbf{A}\boldsymbol{\Lambda} = \begin{bmatrix} \lambda_1 & & & \\ & \lambda_2 & & \\ & & \ddots & \\ & & & \lambda_n \end{bmatrix}$$

$$\begin{Bmatrix} \dot{z}_1 \\ \dot{z}_2 \\ \vdots \\ \dot{z}_n \end{Bmatrix} = \begin{bmatrix} \lambda_1 & 0 & \cdots & 0 \\ 0 & \lambda_2 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & \lambda_n \end{bmatrix} \begin{Bmatrix} z_1 \\ z_2 \\ \vdots \\ z_n \end{Bmatrix} + \begin{bmatrix} \bar{b}_{11} & \cdots & \bar{b}_{1m} \\ \bar{b}_{21} & \cdots & \bar{b}_{2m} \\ \vdots & \ddots & \vdots \\ \bar{b}_{n1} & \cdots & \bar{b}_{nm} \end{bmatrix} \begin{Bmatrix} u_1 \\ \vdots \\ u_m \end{Bmatrix} \longrightarrow$$

$$\begin{aligned} \dot{z}_1 &= \lambda_1 z_1 \\ \dot{z}_2 &= \lambda_2 z_2 \\ &\vdots \\ \dot{z}_n &= \lambda_n z_n \end{aligned}$$

=> $\boxed{z_j(t) = z_j(0)e^{\lambda_j t}} \longrightarrow x_i(t) = v_{1_i} z_1(t) + v_{2_i} z_2(t) + \cdots + v_{n_i} z_n(t)$

SCRIPT

```
% condición de vuelo
h   = 5000; % m
V   = 130 ; % m/s
gam = 0;    % γ
slp = 0;    % β
d   = 3;    % Δα / Δθ [°]
phi = 0;    % [°] roll


mdl = A320_build_model(1, h, V/1.852*3.6, 0, false, false, gam, slp);

% lng:
X0_lng = [0; d*130*pi/180; 0; (d)*pi/180];
A_lng = mdl.lng.A;
[V_lng,D_lng] = eig(A_lng);
A_lng_ = V_lng\(A_lng*V_lng);
Z0_lng = V_lng\X0_lng;
Z_lng = zeros(4,length(t));
X_lng = zeros(4,length(t));

% lng:
X0_lat = [slp*pi/180; 0; 0; phi*pi/180];
A_lat = mdl.lat.A;
[V_lat,D_lat] = eig(A_lat);
Z0_lat = V_lat\X0_lat;
Z_lat = zeros(4,length(t));
X_lat = zeros(4,length(t));

for i = 1:4
  Z_lat(i, :) = Z0_lat(i) * e.^(D_lat(i,i)*t);
  Z_lng(i, :) = Z0_lng(i) * e.^(D_lng(i,i)*t);
endfor

mdl_res.u = X_lng(1, :) + mdl.speed * cosd(mdl.alfa);
mdl_res.w = X_lng(2, :) + mdl.speed * sind(mdl.alfa);
mdl_res.alfa = atand(mdl_res.w./mdl_res.u);
mdl_res.pitch = X_lng(4, :) + mdl.pitch*pi/180;
```

MODELO LINEAL

$$A_{long} = \begin{bmatrix} -0.0016 & 0.0916 & -15.6095 & -9.7386 \\ -0.0886 & -0.5107 & 128.6868 & -1.1813 \\ 0.0022 & -0.0166 & -0.7595 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix}$$

MODELO LINEAL

$$A_{long} = \begin{bmatrix} -0.0016 & 0.0916 & -15.6095 & -9.7386 \\ -0.0886 & -0.5107 & 128.6868 & -1.1813 \\ 0.0022 & -0.0166 & -0.7595 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix}$$

$$V_{long} = \begin{bmatrix} -0.0990 + 0.0151i & -0.0990 - 0.0151i & -0.9963 & -0.9963 \\ 0.9949 & 0.9949 & -0.0855 + 0.0042i & -0.0855 - 0.0042i \\ -0.0010 + 0.0113i & -0.0010 - 0.0113i & -0.0010 & -0.0010 \\ 0.0067 - 0.0023i & 0.0067 + 0.0023i & 0.0007 + 0.0102i & 0.0007 - 0.0102i \end{bmatrix}$$

MODELO LINEAL

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$$D_{long} = \begin{bmatrix} -0.633145 + 1.464589i \\ -0.633145 - 1.464589i \\ -0.002716 + 0.099902i \\ -0.002716 - 0.099902i \end{bmatrix}$$

MODELO LINEAL

$$A_{long} = \begin{bmatrix} -0.0016 & 0.0916 & -15.6095 & -9.7386 \\ -0.0886 & -0.5107 & 128.6868 & -1.1813 \\ 0.0022 & -0.0166 & -0.7595 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix}$$

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MODELO LINEAL

$$A_{lat} = \begin{bmatrix} -0.0894 & 0.1202 & -0.9927 & 0.0749 \\ -2.5220 & -0.6859 & 0.4045 & 0 \\ 0.5670 & -0.0649 & -0.1542 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix}$$

MODELO LINEAL

$$A_{lat} = \begin{bmatrix} -0.0894 & 0.1202 & -0.9927 & 0.0749 \\ -2.5220 & -0.6859 & 0.4045 & 0 \\ 0.5670 & -0.0649 & -0.1542 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix}$$

$$V_{lat} = \begin{bmatrix} 0.2426 - 0.1689i & 0.2426 + 0.1689i & 0.0300 & 0.0158 \\ -0.0430 + 0.6518i & -0.0430 - 0.6518i & 0.6167 & -0.0159 \\ -0.1271 - 0.1554i & -0.1271 + 0.1554i & 0.0364 & 0.0722 \\ 0.6675 & 0.6675 & -0.7858 & 0.9971 \end{bmatrix}$$

MODELO LINEAL

$$A_{lat} = \begin{bmatrix} -0.0894 & 0.1202 & -0.9927 & 0.0749 \\ -2.5220 & -0.6859 & 0.4045 & 0 \\ 0.5670 & -0.0649 & -0.1542 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix}$$

$$D_{lat} = \begin{bmatrix} -0.0644 + 0.9764i \\ -0.0644 - 0.9764i \\ -0.7848 \\ -0.0159 \end{bmatrix}$$

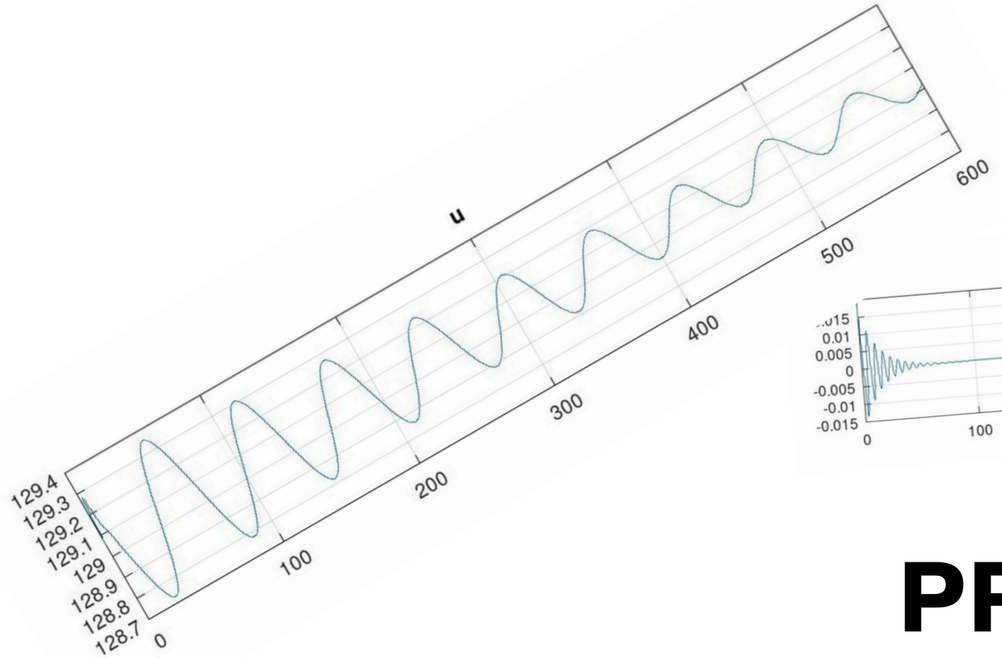
$$V_{lat} = \begin{bmatrix} 0.2426 - 0.1689i & 0.2426 + 0.1689i & 0.0300 & 0.0158 \\ -0.0430 + 0.6518i & -0.0430 - 0.6518i & 0.6167 & -0.0159 \\ -0.1271 - 0.1554i & -0.1271 + 0.1554i & 0.0364 & 0.0722 \\ 0.6675 & 0.6675 & -0.7858 & 0.9971 \end{bmatrix}$$

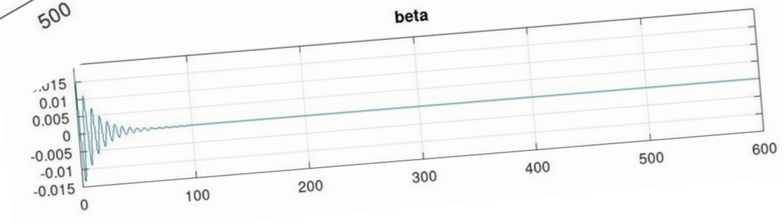
MODELO LINEAL

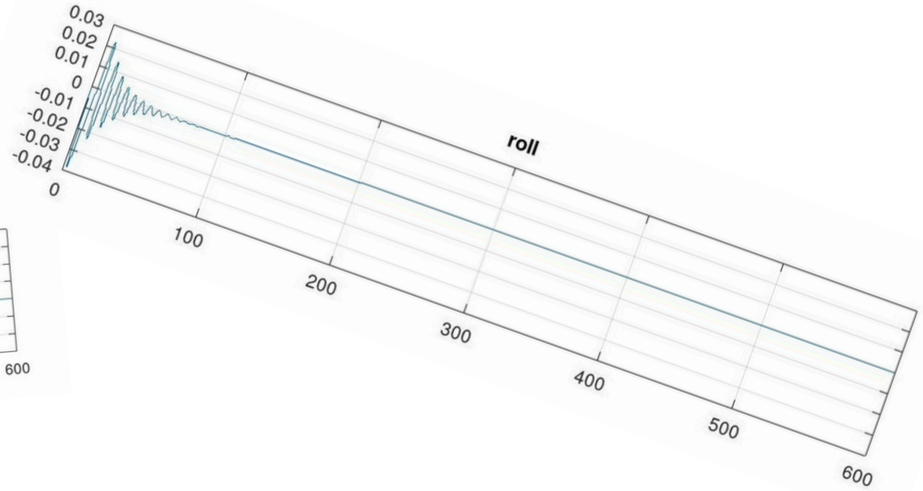
$$A_{lat} = \begin{bmatrix} -0.0894 & 0.1202 & -0.9927 & 0.0749 \\ -2.5220 & -0.6859 & 0.4045 & 0 \\ 0.5670 & -0.0649 & -0.1542 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix}$$

$$D_{lat} = \begin{bmatrix} -0.0644 + 0.9764i \\ -0.0644 - 0.9764i \\ -0.7848 \\ -0.0159 \end{bmatrix}$$

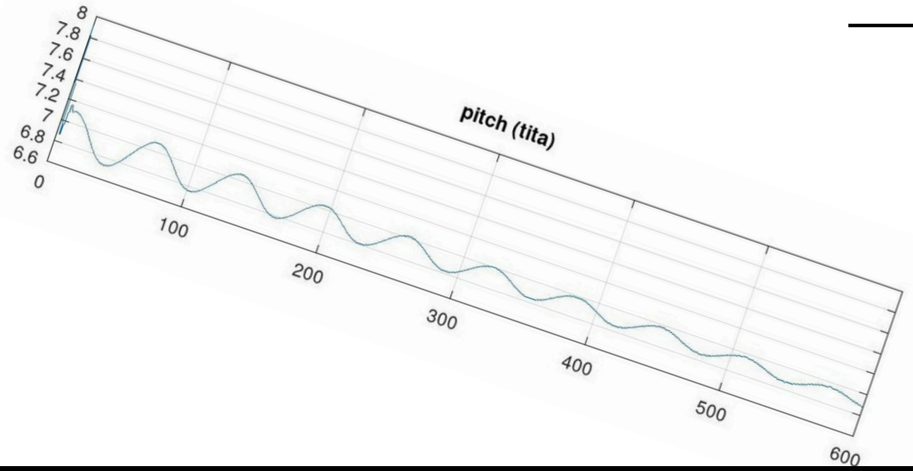
$$V_{lat} = \begin{bmatrix} 0.2426 - 0.1689i & 0.2426 + 0.1689i & 0.0300 & 0.0158 \\ -0.0430 + 0.6518i & -0.0430 - 0.6518i & 0.6167 & -0.0159 \\ -0.1271 - 0.1554i & -0.1271 + 0.1554i & 0.0364 & 0.0722 \\ 0.6675 & 0.6675 & -0.7858 & 0.9971 \end{bmatrix}$$

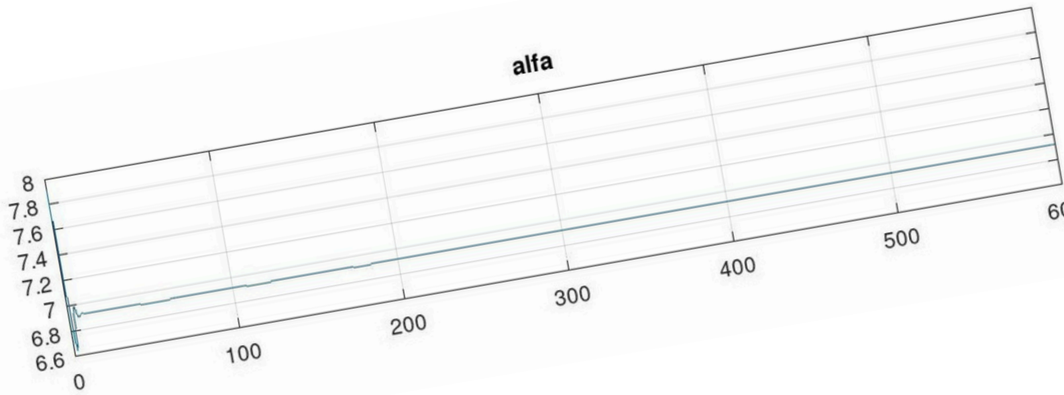




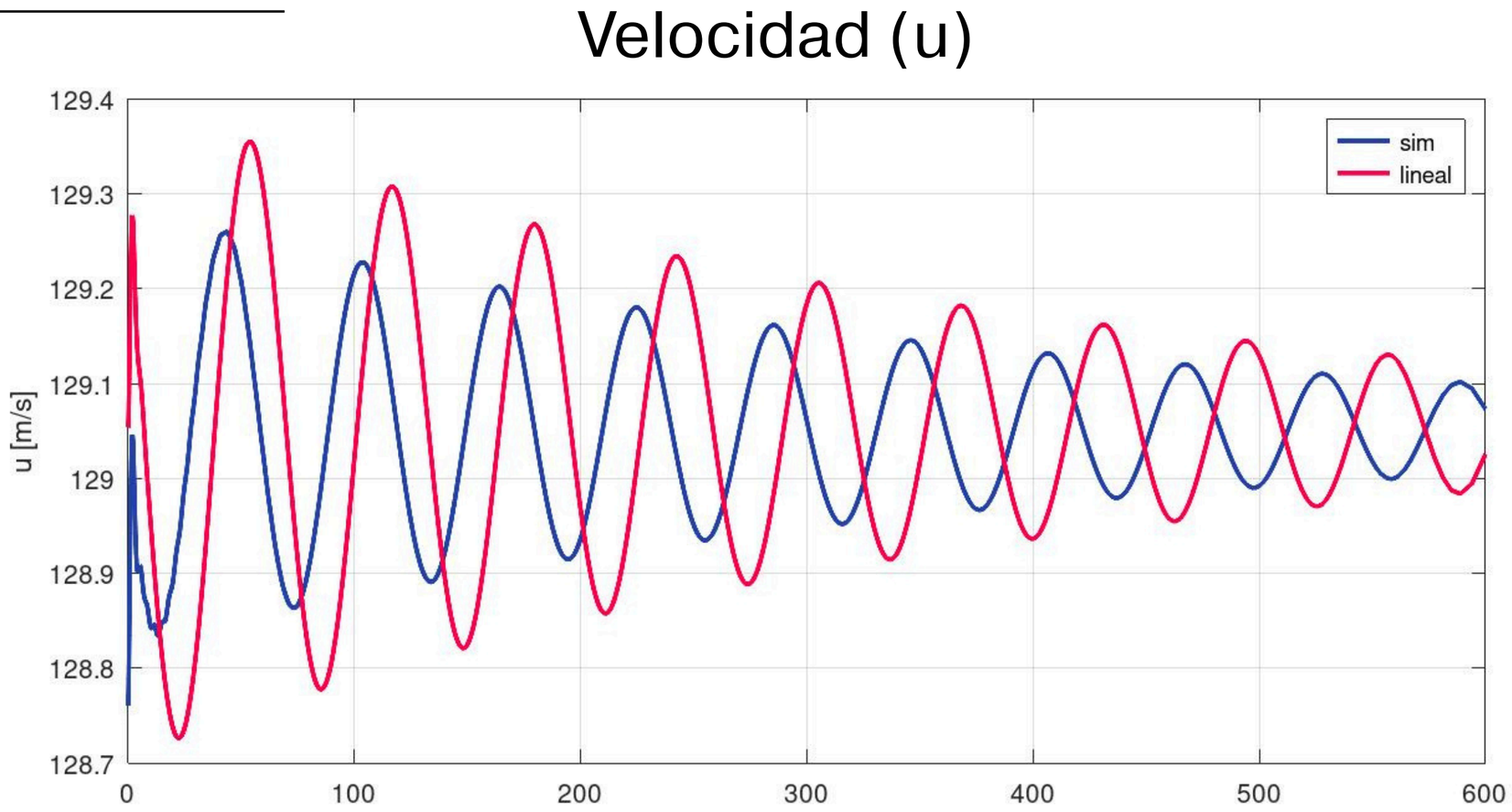


PRIMEROS RESULTADOS



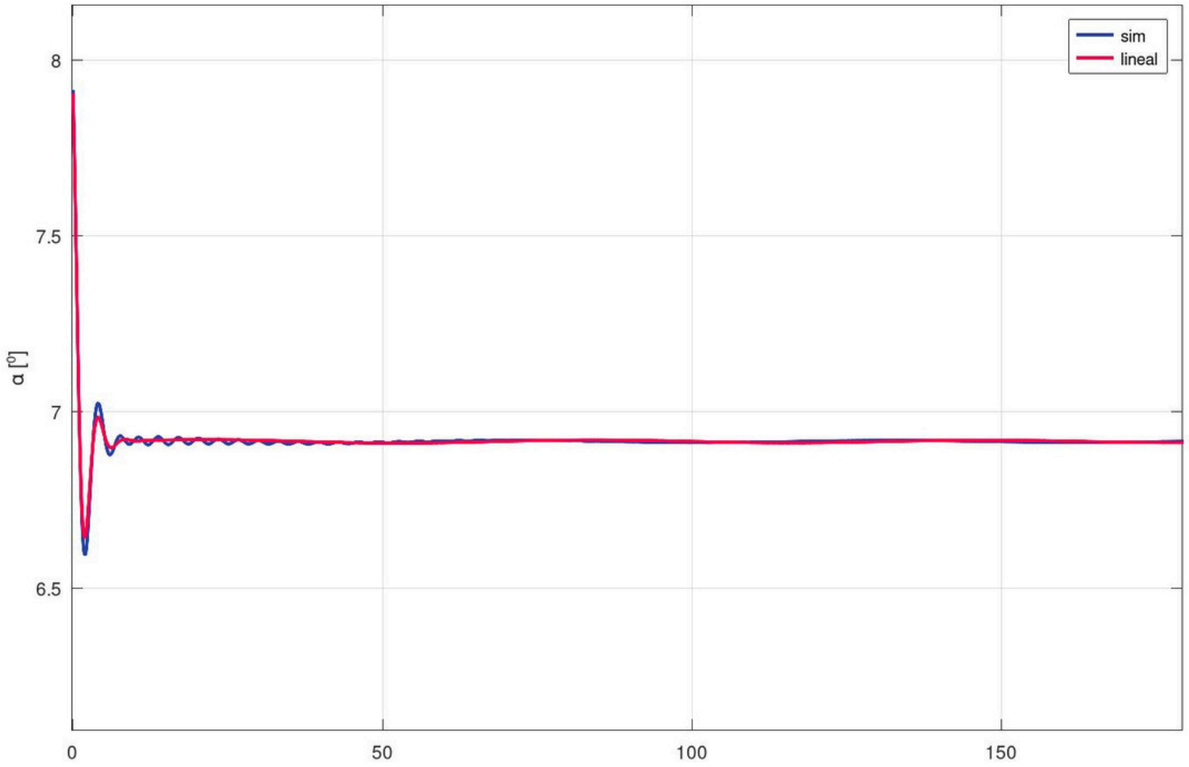


PRIMEROS RESULTADOS



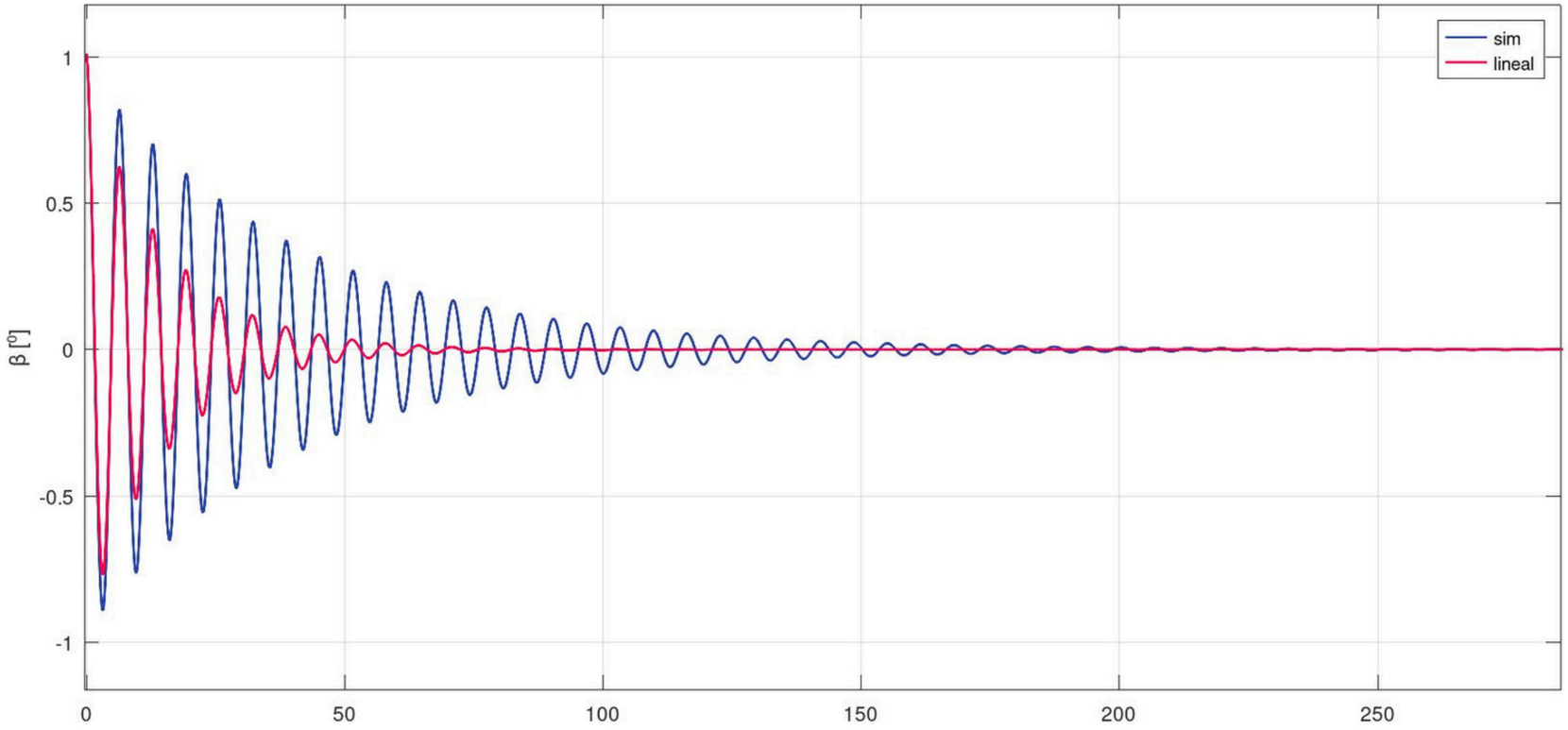
PRIMEROS RESULTADOS

Angulo de ataque (α)



PRIMEROS RESULTADOS

Angulo de deslizamiento (β)



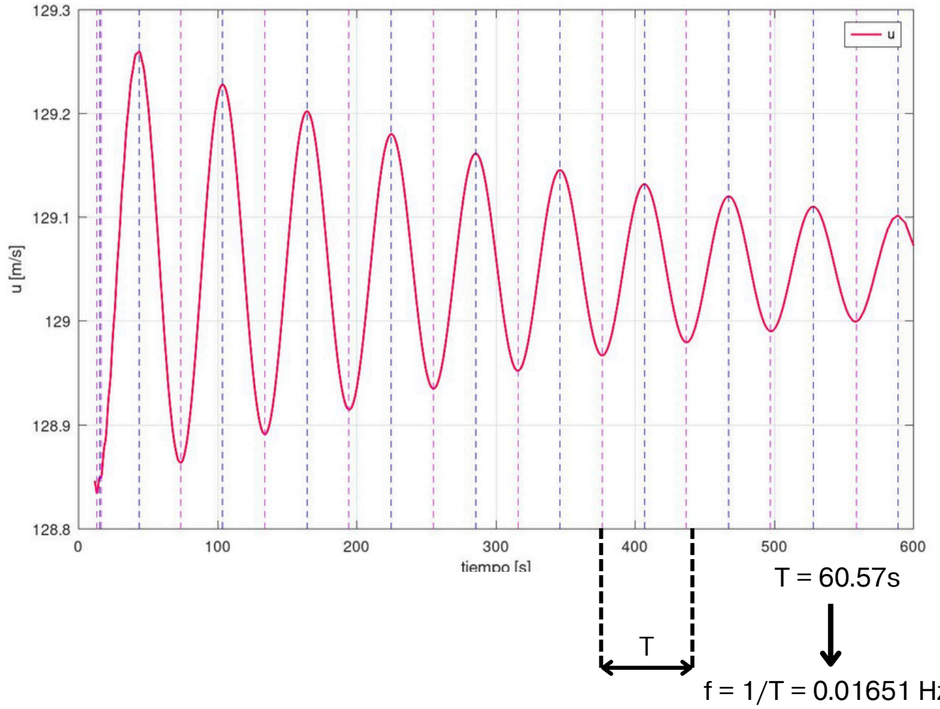
ANALISIS
DE MODOS

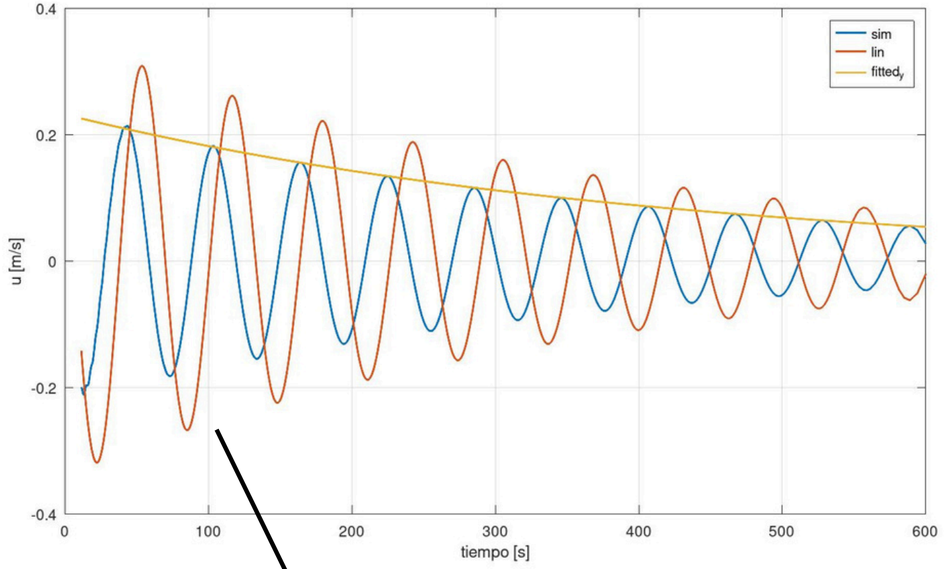
ANALISIS LONG
MODO LENTO

$\Delta\alpha = 1°$

$$D_{long} = \begin{bmatrix} -0.633145 + 1.464589i \\ -0.633145 - 1.464589i \\ -0.002716 + 0.099902i \\ -0.002716 - 0.099902i \end{bmatrix}$$

$$\begin{cases} f = \omega/2\pi = im(D_3)/2\pi = 0.0159 \text{ Hz} \\ amort = re(D_3) = -0.002716 \end{cases}$$





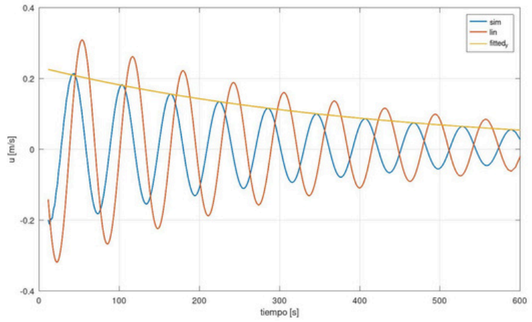
ANALISIS LONG MODO LENTO

Condiciones de vuelo:

h = 5000m v = 130m/s β = 0°

AoA = 6.91° y = 0° roll = 0°

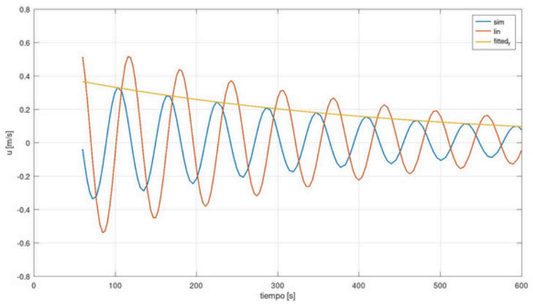
Δα = 1°



f_{real} = 0.016509 Hz
f_{lineal} = 0.0159 Hz → error: 3.7%

am_{real} = -0.002605
am_{lineal} = -0.002716 → error: 4.3%

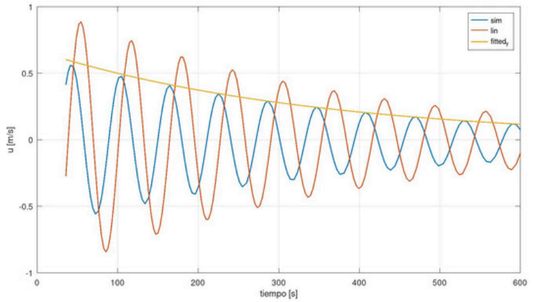
Δα = 2°



f_{real} = 0.01668 Hz
f_{lineal} = 0.0159 Hz → error: 4.7%

am_{real} = -0.002462
am_{lineal} = -0.002716 → error: 10.3%

Δα = 3°



f_{real} =0.015735 Hz
f_{lineal} = 0.0159 Hz → error: 1%

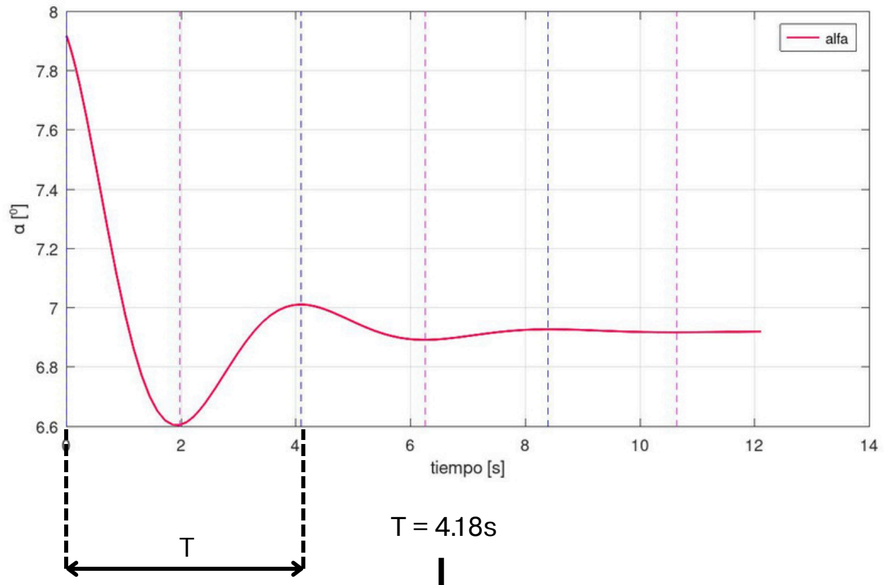
am_{real} = -0.002912
am_{lineal} = -0.002716 → error: 6.7%

ANALISIS LONG MODO RAPIDO

$\Delta\alpha = 1°$

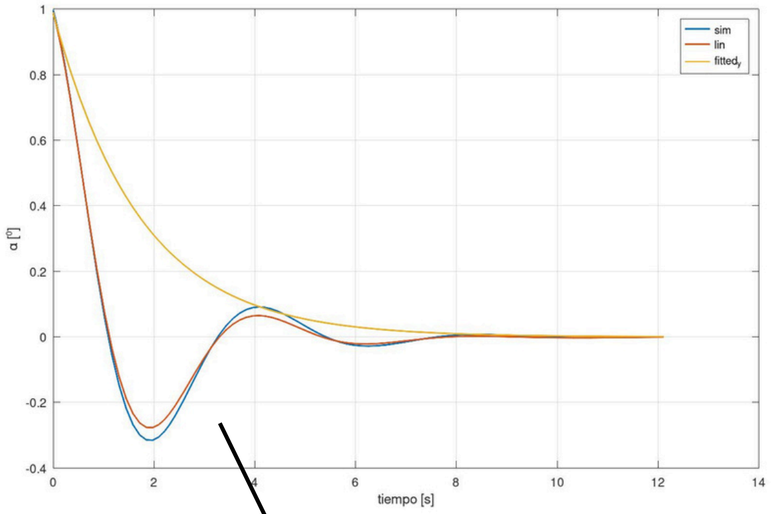
$$D_{long} = \begin{bmatrix} -0.633145 + 1.464589i \\ -0.633145 - 1.464589i \\ -0.002716 + 0.099902i \\ -0.002716 - 0.099902i \end{bmatrix}$$

$$\begin{cases} f = \omega/2\pi = im(D_1)/2\pi = 0.2331 \text{ Hz} \\ amort = re(D_1) = -0.633145 \end{cases}$$



T = 4.18s

f = 1/T = 0.239113 Hz



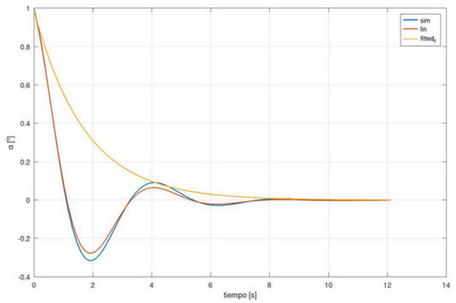
$fit = \gamma e^{\lambda t}$ $\lambda = -0.580791$

ANALISIS LONG MODO RAPIDO

Condiciones de vuelo:

h = 5000m	v = 130m/s	β = 0°
AoA = 6.91°	y = 0°	roll = 0°

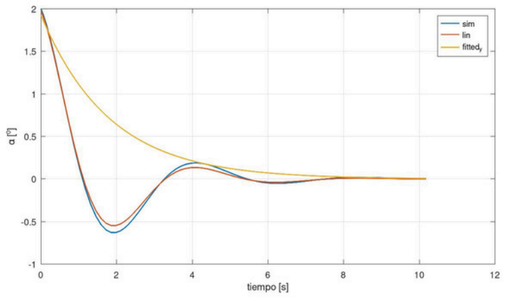
Δα = 1°



f_{real} = 0.239113 Hz
f_{lineal} = 0.2331 Hz → error: 2.5%

am_{real} = -0.580791
am_{lineal} = -0.633145 → error: 9.0%

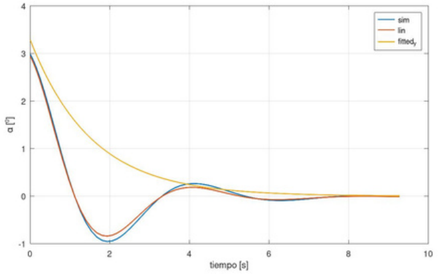
Δα = 2°



f_{real} = 0.238361 Hz
f_{lineal} = 0.2331 Hz → error: 2.2%

am_{real} = -0.551022
am_{lineal} = -0.633145 → error: 14.9%

Δα = 3°

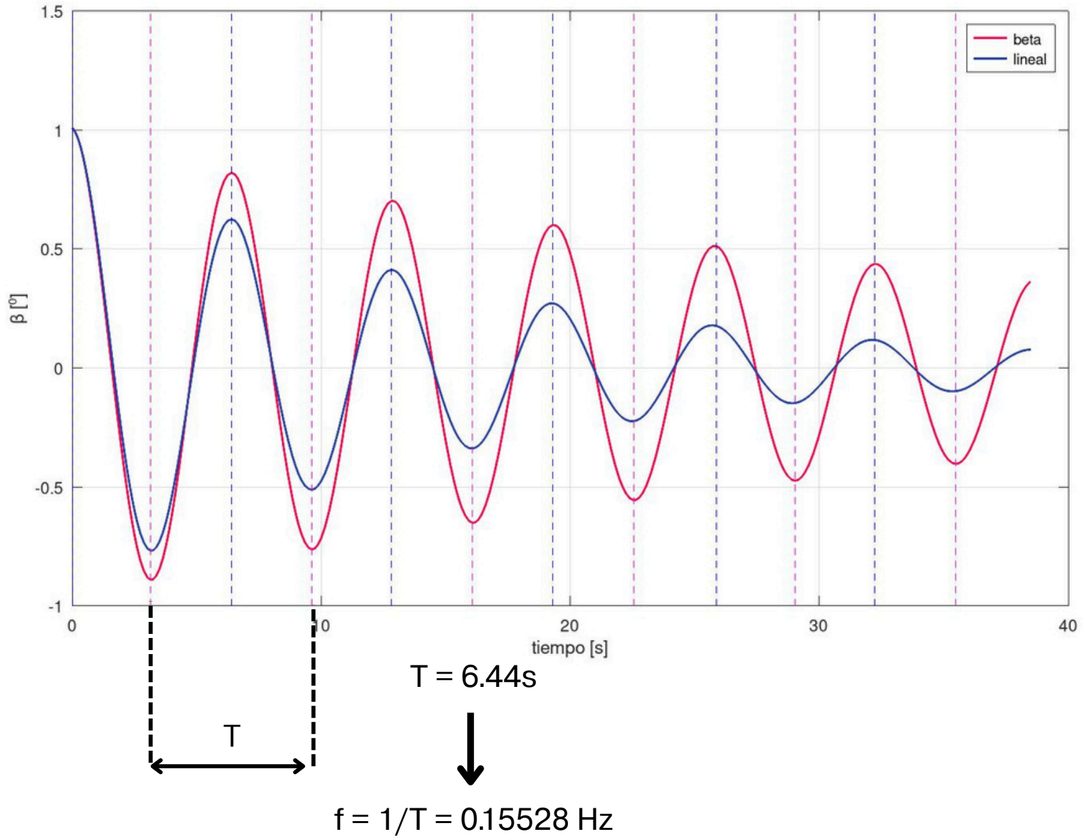


f_{real} = 0.233881 Hz
f_{lineal} = 0.2331 Hz → error: 0.3%

am_{real} = -0.653547
am_{lineal} = -0.633145 → error: 3.1%

ANALISIS LAT

$\Delta\beta = 1°$



$$D_{long} = \begin{bmatrix} -0.06438 + 0.97645i \\ -0.06438 - 0.97645i \\ -0.78483 \\ -0.015906 \end{bmatrix}$$

$$f = \omega/2\pi = im(D_1)/2\pi = 0.15541 \text{ Hz}$$

ANALISIS LAT

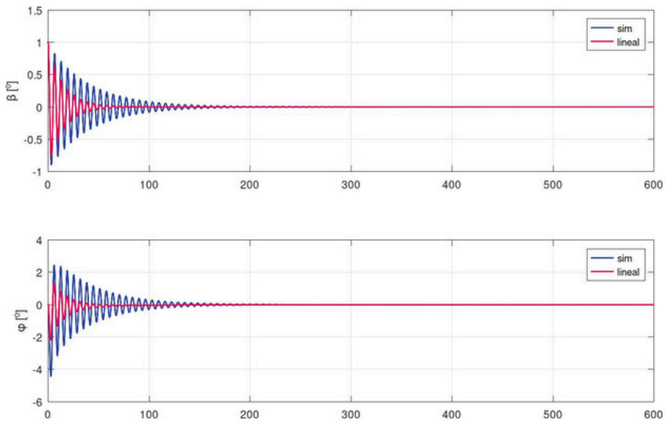
Condiciones de vuelo:

h = 5000m v = 130m/s

AoA = 6.91° y = 0°

$\Delta\beta = 1°$

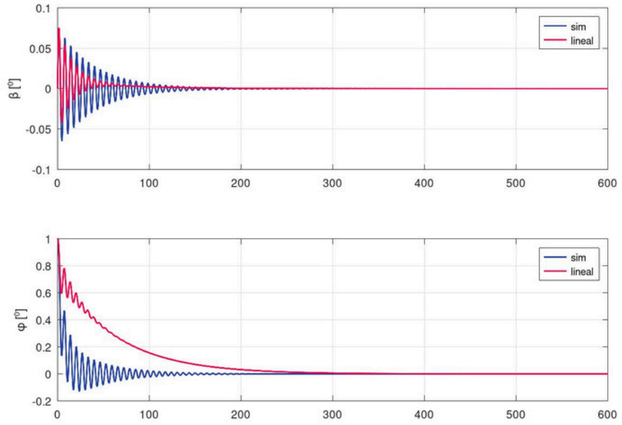
$\Delta\varphi = 0°$



$\begin{cases} f_{real} = 0.156084\ Hz \\ f_{lineal} = 0.155407\ Hz \end{cases} \longrightarrow$ error: 0.4%

$\Delta\beta = 0°$

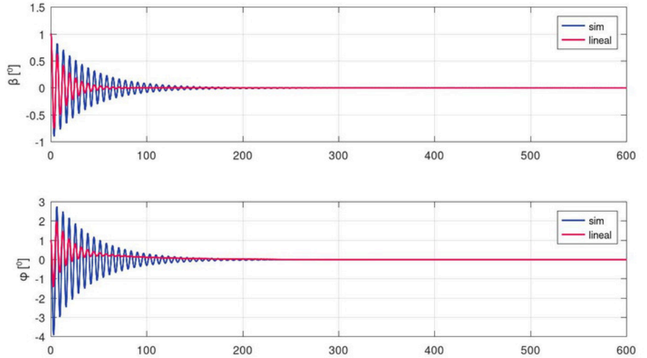
$\Delta\varphi = 1°$



$\begin{cases} f_{real} = 0.178618\ Hz \\ f_{lineal} = 0.155407\ Hz \end{cases} \longrightarrow$ error: 13.0%

$\Delta\beta = 1°$

$\Delta\varphi = 1°$



$\begin{cases} f_{real} = 0.153937\ Hz \\ f_{lineal} = 0.155407\ Hz \end{cases} \longrightarrow$ error: 1.0%

COMPUESTO

Condiciones de vuelo:

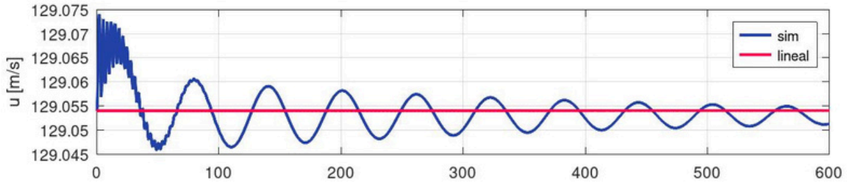
h = 5000m v = 130m/s

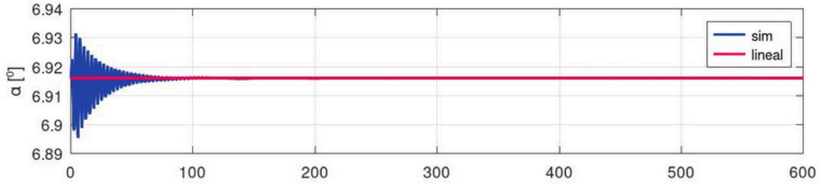
AoA = 6.91° γ = 0°

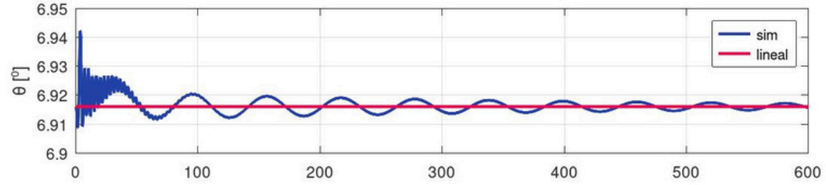
$\Delta\alpha = 0°$

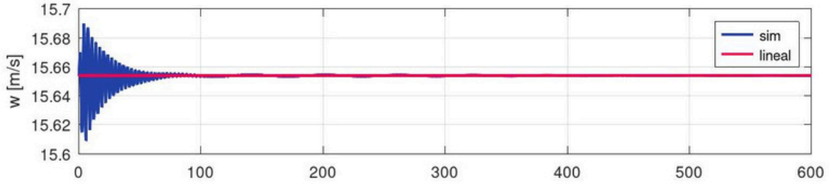
$\Delta\beta = 1°$

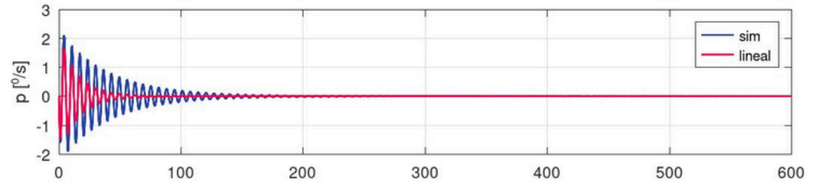
$\Delta\varphi = 1°$

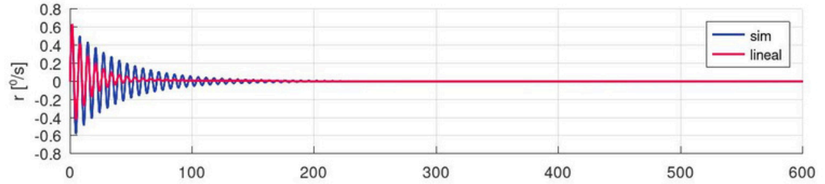


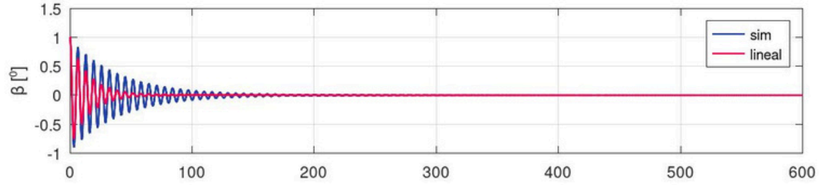


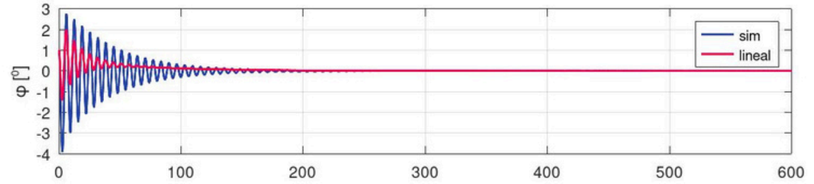








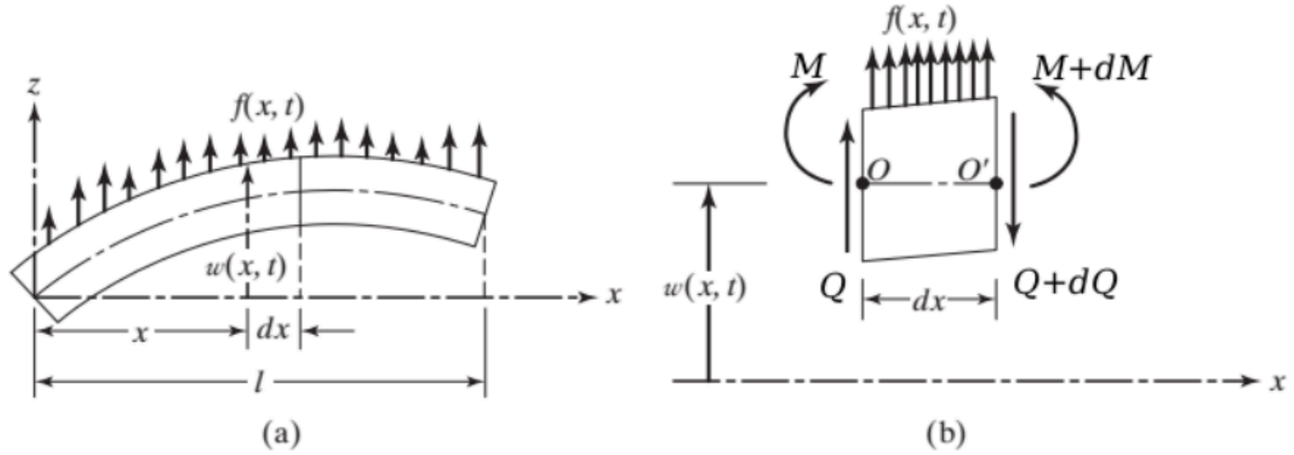




A2

DEFORMACION DE ALAS A FLEXION

PARAMETROS DISTRIBUIDOS



$$\Sigma F \quad \rho A(x)dx\,\frac{\partial^2 w(x,t)}{\partial t^2} = -\,(Q(x,t)+dQ) + f(x,t)dx + Q(x,t)$$

$$\Sigma M_o \quad (M(x,t)+dM) - (Q(x,t)+dQ)\,dx + f(x,t)dx\frac{dx}{2} - M = 0$$

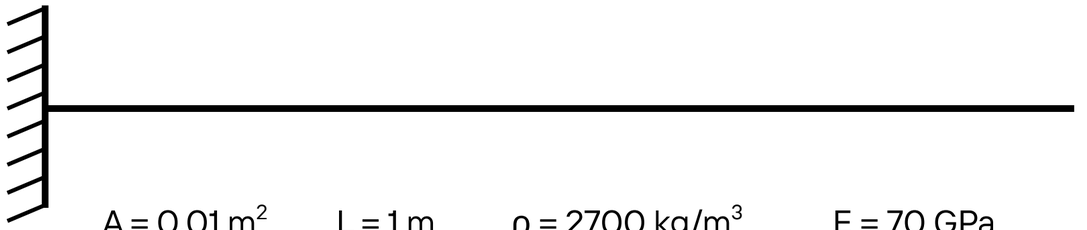
$$\Rightarrow \quad \boxed{\frac{\partial^2}{\partial x^2}\left[EI(x)\frac{\partial^2 w(x,t)}{\partial x^2}\right] + \mu(x)\frac{\partial^2 w(x,t)}{\partial t^2} = f(x,t)}$$

0

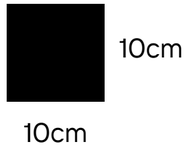
$$w(x,t) = y(x)q(t) \quad \Rightarrow \quad \begin{cases} \dfrac{d^2}{dx^2}\left[EI(x)\dfrac{d^2 y(x)}{dx^2}\right] - \omega^2 \rho A(x) y(x) = 0 \\ \dfrac{d^2 q(t)}{dt^2} + \omega^2 q(t) = 0 \longrightarrow q(t) = a\,\cos\omega t + b\,\sin\omega t \end{cases}$$

PARAMETROS DISTRIBUIDOS

Viga uniforme ⟶ EI = cte, ρA = cte



A = 0.01 m^2 L = 1 m ρ = 2700 kg/m^3 E = 70 GPa



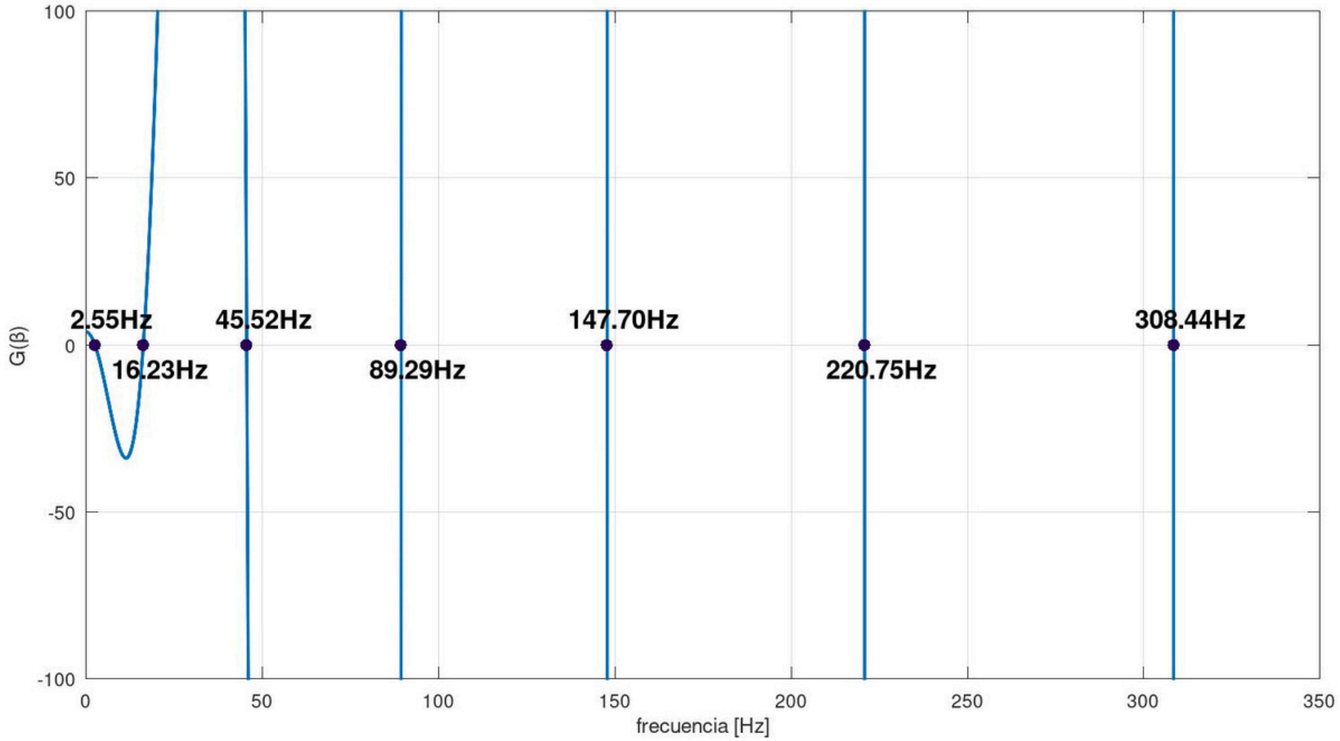
$$\frac{d^4y}{dx^4}(x) - \beta^4 y(x) = 0 \qquad \beta^4 = \mu\frac{\omega^2}{EI} \quad \Rightarrow \quad y(x) = A\cosh\beta x + B\sinh\beta x + C\cos\beta x + D\sin\beta x$$

Condiciones de borde

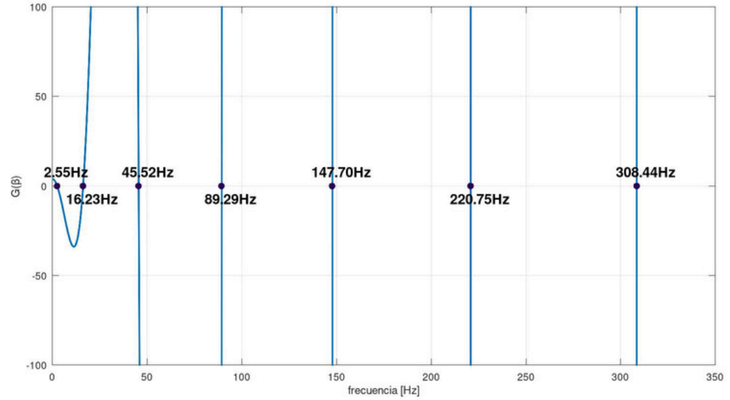
$$\begin{cases} y(0) = 0 \\ y'(0) = 0 \\ y''(L) = 0 \\ y'''(L) = 0 \end{cases} \Rightarrow \quad \boxed{G(\beta) = (\cosh(\beta L) + \cos(\beta L))^2 - (\sinh(\beta L) - \sin(\beta L))\,(\sinh(\beta L) + \sin(\beta L)) = 0}$$

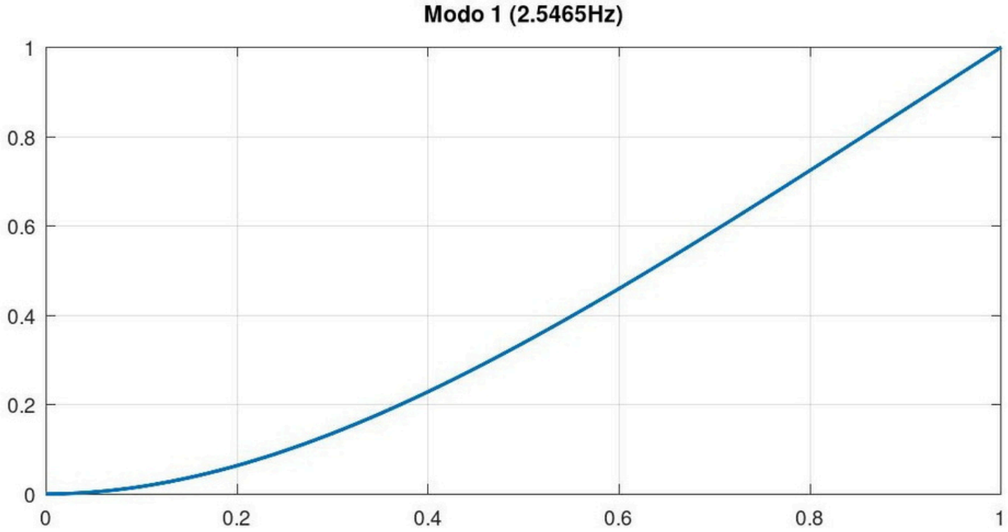
PARAMETROS DISTRIBUIDOS

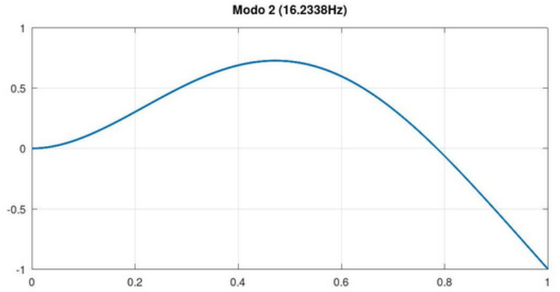
Resolviendo numericamente

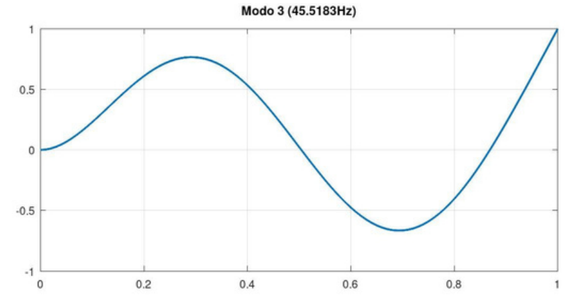


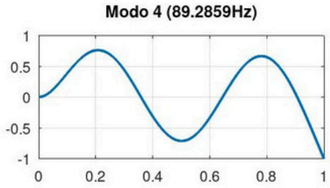
PARAMETROS DISTRIBUIDOS

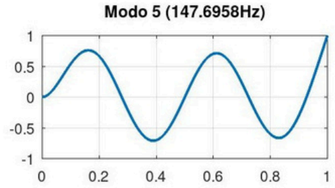


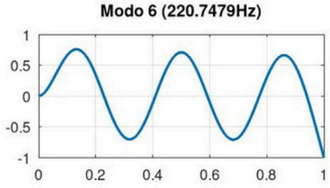


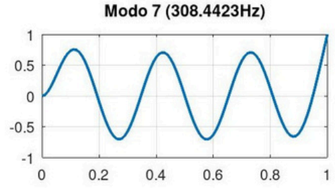




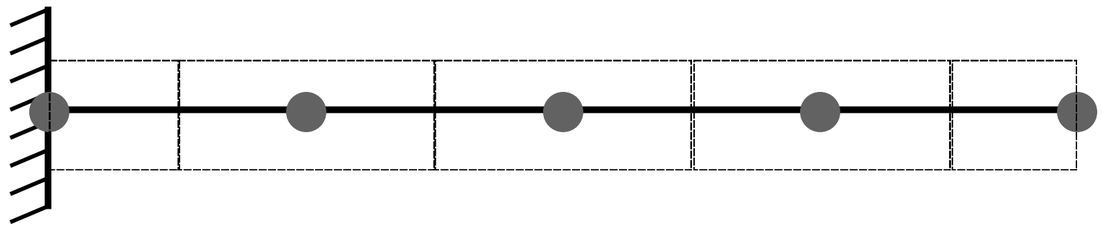








PARAMETROS CONCENTRADOS

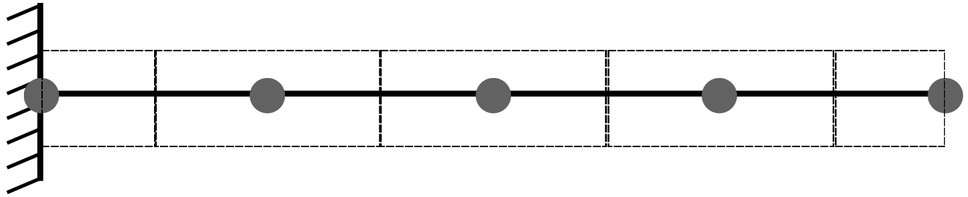


$$\mathbf{M}\,\ddot{\boldsymbol{q}} + \mathbf{D}\,\dot{\boldsymbol{q}} + \mathbf{K}\,\boldsymbol{q} = \mathbf{F}\,\boldsymbol{u} \longrightarrow \ddot{\boldsymbol{q}} + [\mathbf{M}^{-1}\mathbf{D}]\,\dot{\boldsymbol{q}} + [\mathbf{M}^{-1}\mathbf{K}]\,\boldsymbol{q} = [\mathbf{M}^{-1}\mathbf{F}]\,\boldsymbol{u} \longrightarrow \ddot{\boldsymbol{q}} + \bar{\mathbf{K}}\,\boldsymbol{q} = \bar{\mathbf{F}}\,\boldsymbol{u}$$

0

$$\begin{Bmatrix}\dot{\boldsymbol{q}}\\ \ddot{\boldsymbol{q}}\end{Bmatrix} = \begin{bmatrix}\mathbf{0} & \mathbf{I}\\ -\bar{\mathbf{K}} & \mathbf{0}\end{bmatrix}\begin{Bmatrix}\boldsymbol{q}\\ \dot{\boldsymbol{q}}\end{Bmatrix} + \begin{bmatrix}\mathbf{0}\\ \bar{\mathbf{F}}\end{bmatrix}\{\boldsymbol{u}\} \quad \Rightarrow \quad \begin{cases} s = \pm j\sqrt{\lambda_i} \longrightarrow \omega_i = \sqrt{\lambda_i} \\ \boldsymbol{q} = \boldsymbol{\Lambda\eta} \end{cases}$$

PARAMETROS CONCENTRADOS



$$\Lambda = \begin{bmatrix} 0.0019979 & 0.028947 & 0.016156 & 0.082385 & 0.050558 & -0.071548 & -0.057085 & 0.035277 \\ 0.0071052 & 0.53369 & 0.78439 & -0.83293 & 0.041784 & -0.28742 & -0.33566 & 0.26521 \\ 0.014242 & -0.011127 & -0.077423 & -0.03621 & -0.029898 & -0.04039 & -0.11043 & 0.12412 \\ 0.1892 & 0.81147 & -0.23335 & 0.40469 & -0.46709 & 0.5132 & -0.014568 & 0.42954 \\ 0.025886 & -0.034163 & 0.062243 & 0.021099 & 0.0046728 & 0.06203 & -0.047224 & 0.24257 \\ 0.76871 & 0.14583 & -0.43833 & -0.31024 & 0.6184 & 0.10856 & 0.51064 & 0.50568 \\ -0.083922 & 0.01986 & -0.034797 & -0.012394 & 0.012454 & -0.032388 & 0.11878 & 0.37207 \\ 0.60695 & -0.18141 & 0.35609 & 0.19368 & -0.62772 & -0.79409 & 0.77109 & 0.5249 \end{bmatrix}$$

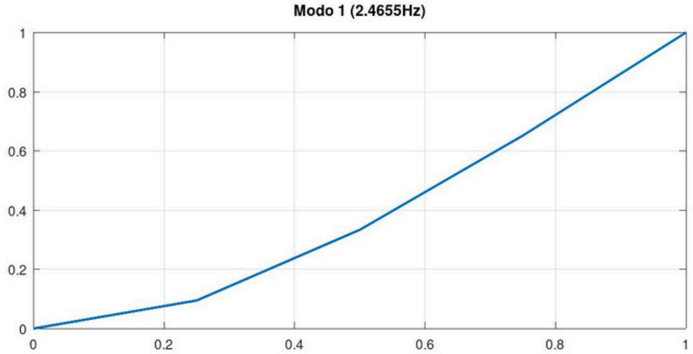
v_1

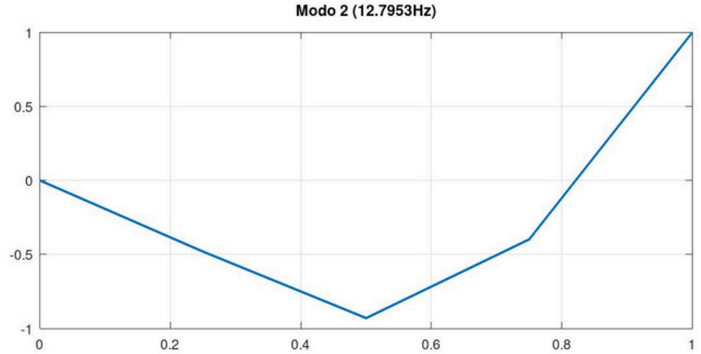
$$D = \begin{bmatrix} 4.4528e{+}05 \\ 3.9082e{+}05 \\ 3.3097e{+}05 \\ 2.0266e{+}05 \\ 95342 \\ 35765 \\ 6463.4 \\ 239.97 \end{bmatrix}$$

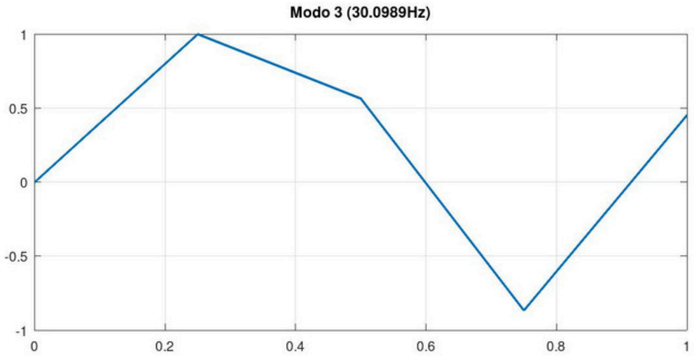
$$f_1 = \frac{\sqrt{D_1}}{2\pi} = 2.4655Hz$$

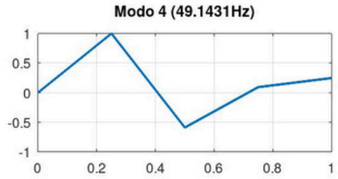
PARAMETROS CONCENTRADOS

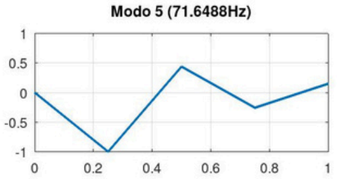
5 Nodos

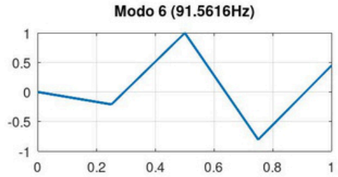


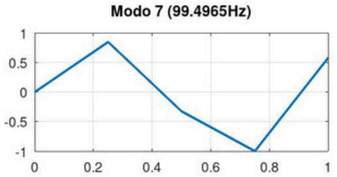






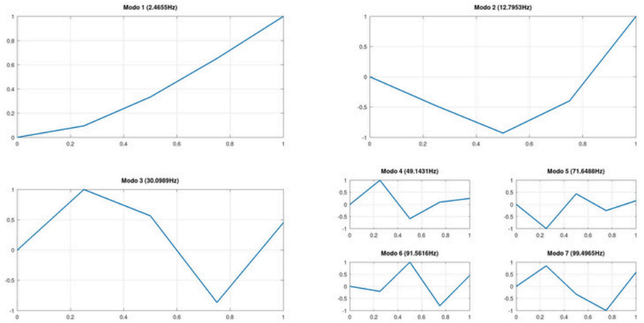






PARAMETROS CONCENTRADOS

5 Nodos



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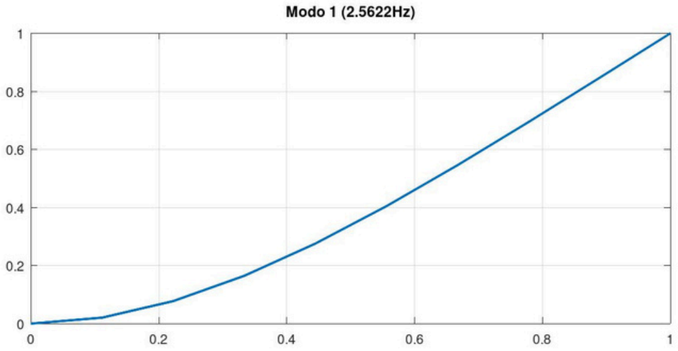
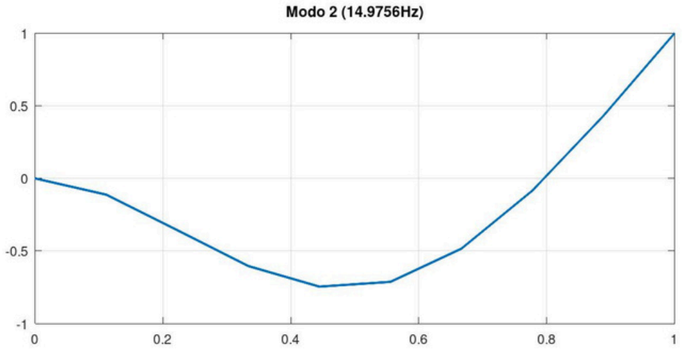
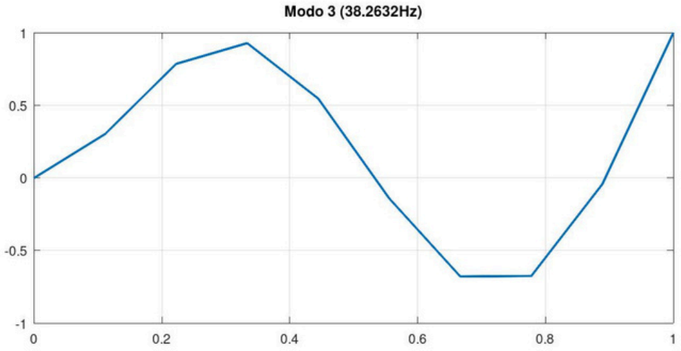
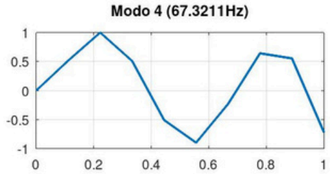
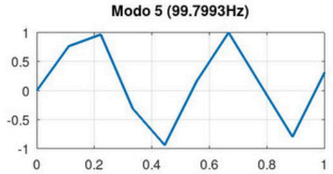
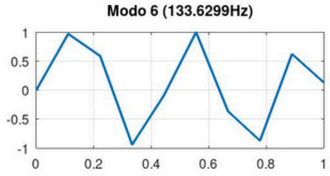


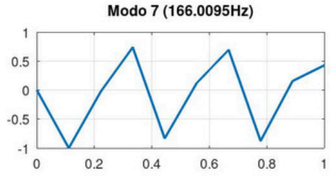






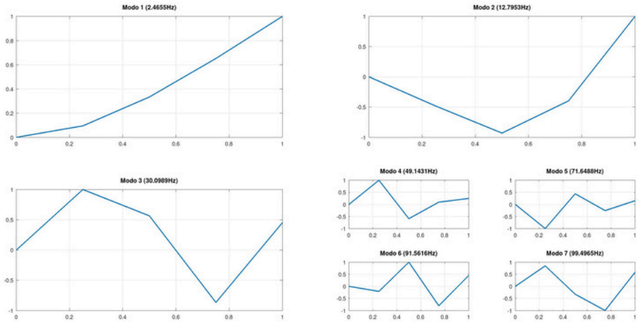




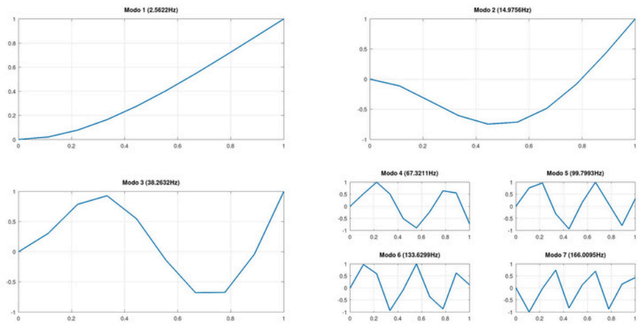


PARAMETROS CONCENTRADOS

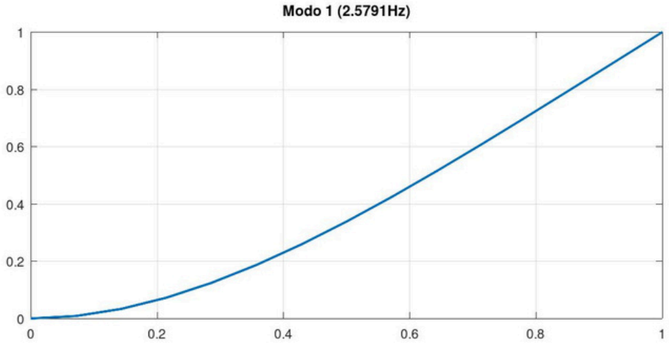
5 Nodos

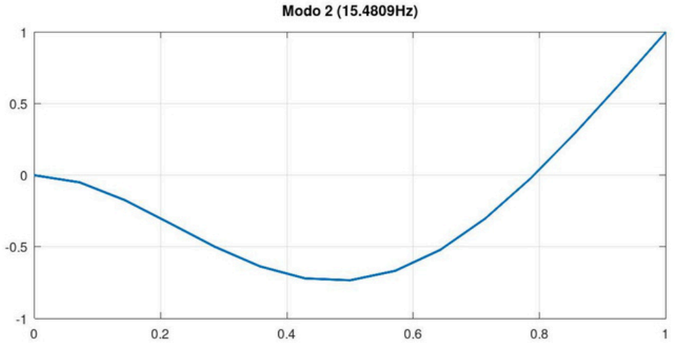


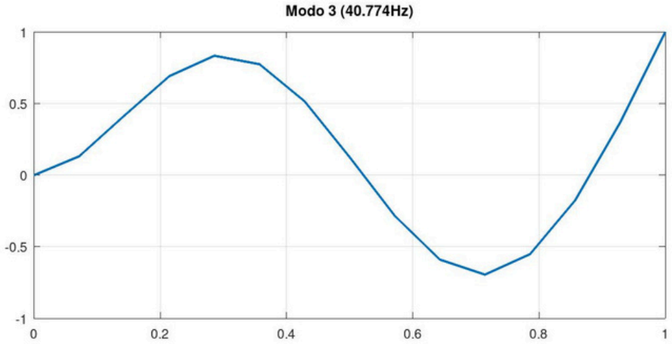
10 Nodos

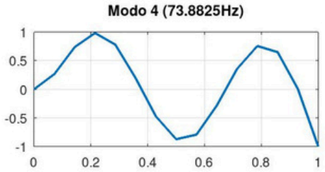


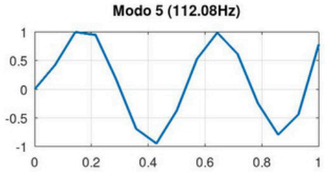
15 Nodos

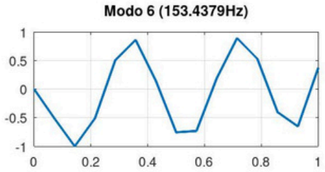


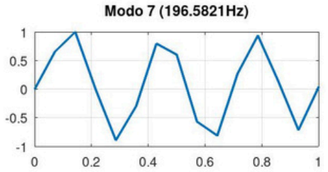






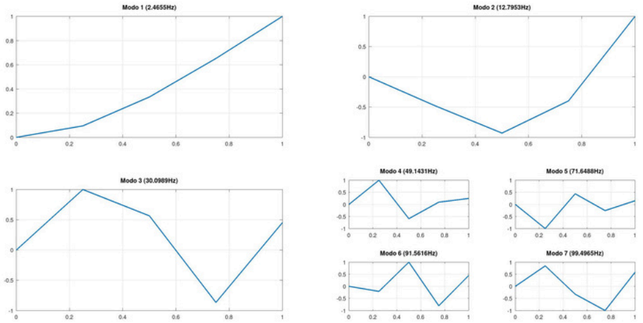




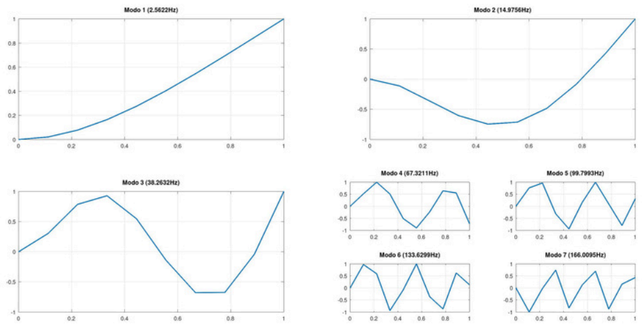


PARAMETROS CONCENTRADOS

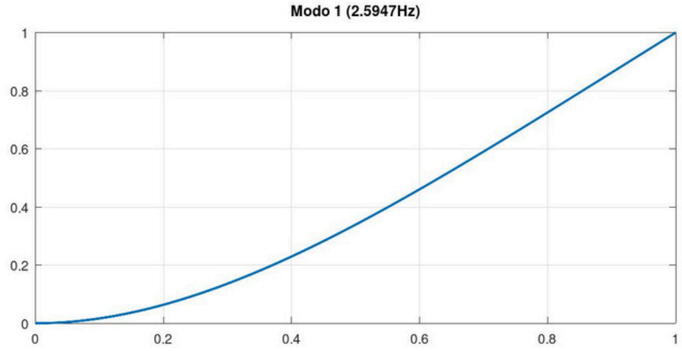
5 Nodos

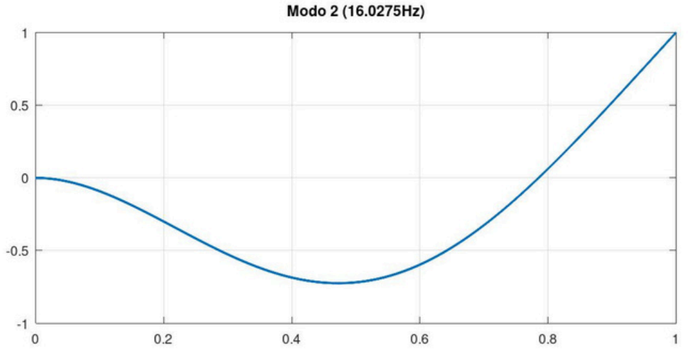


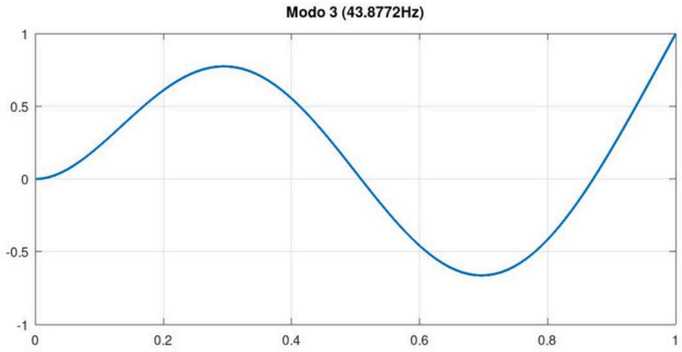
10 Nodos

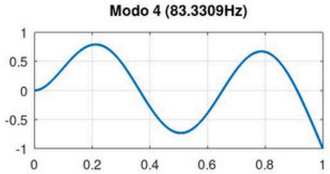


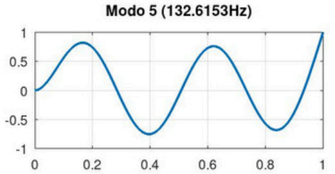
100 Nodos

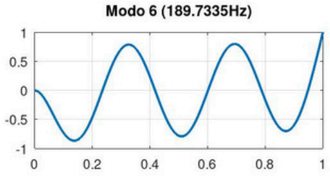


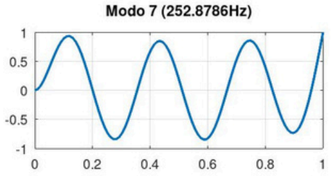




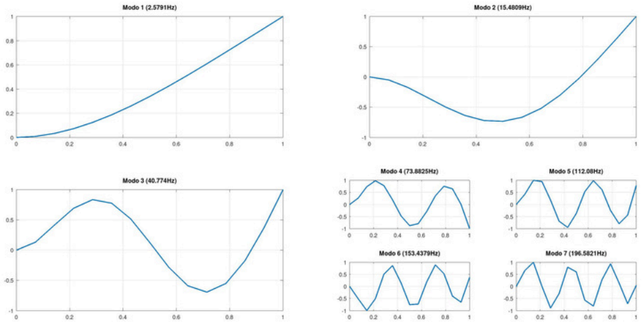




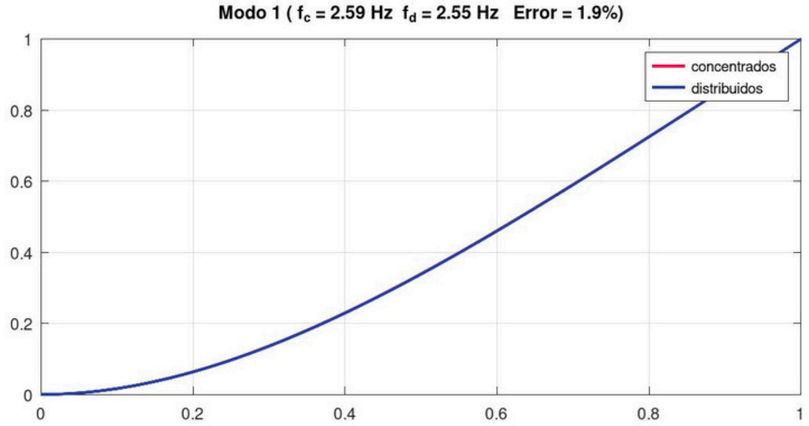


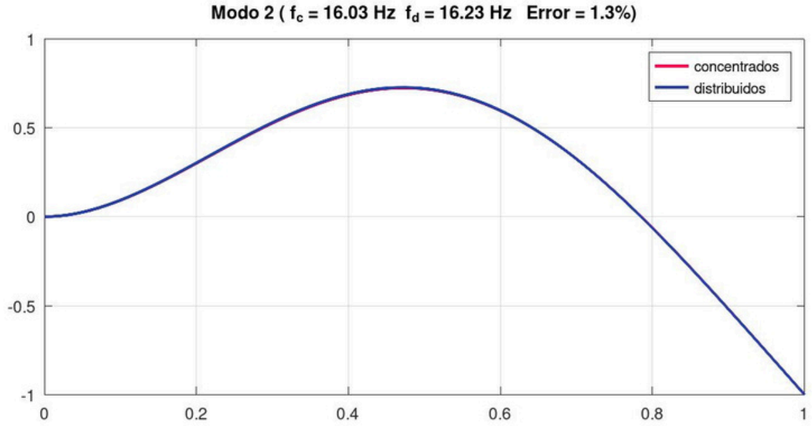


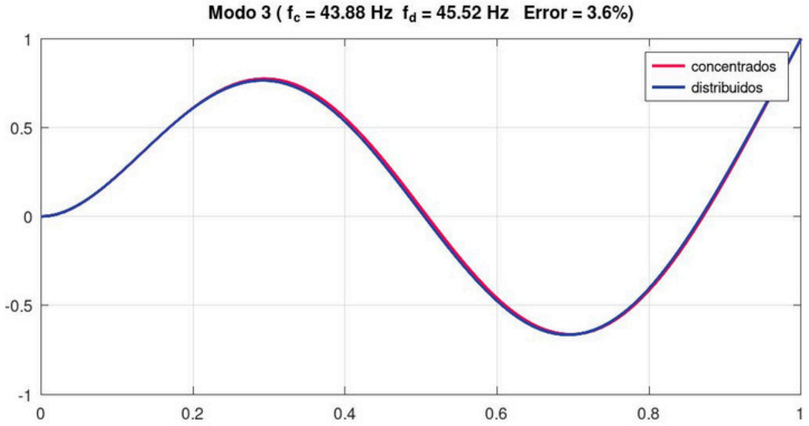
15 Nodos

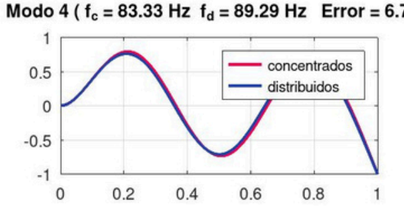


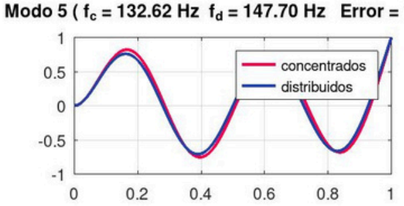
COMPARACION

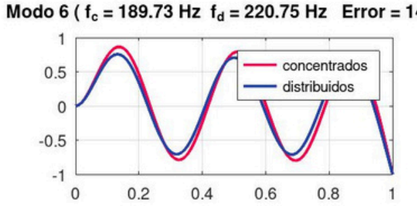


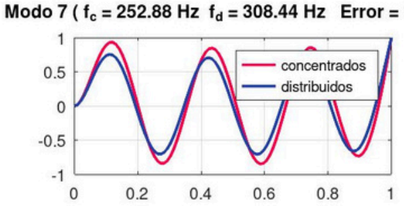






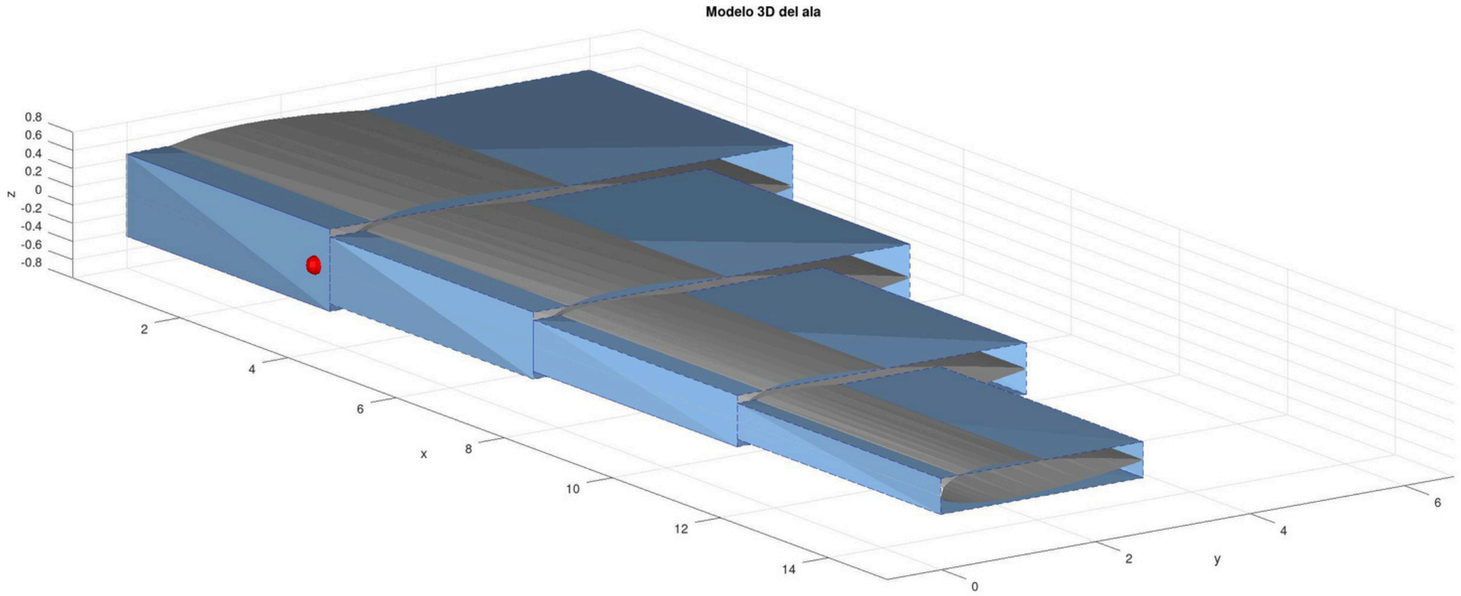


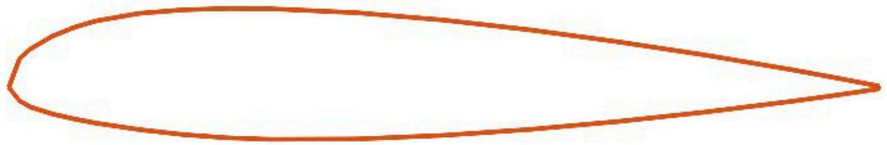


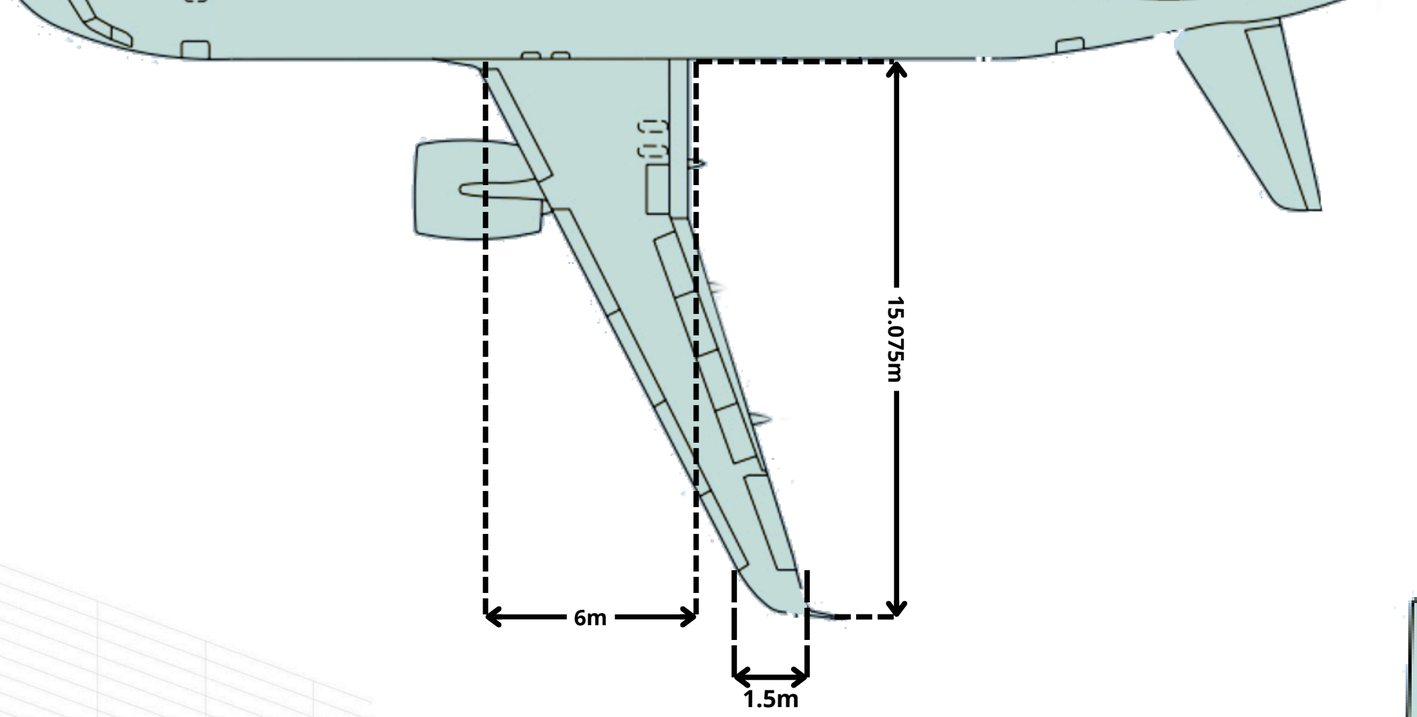


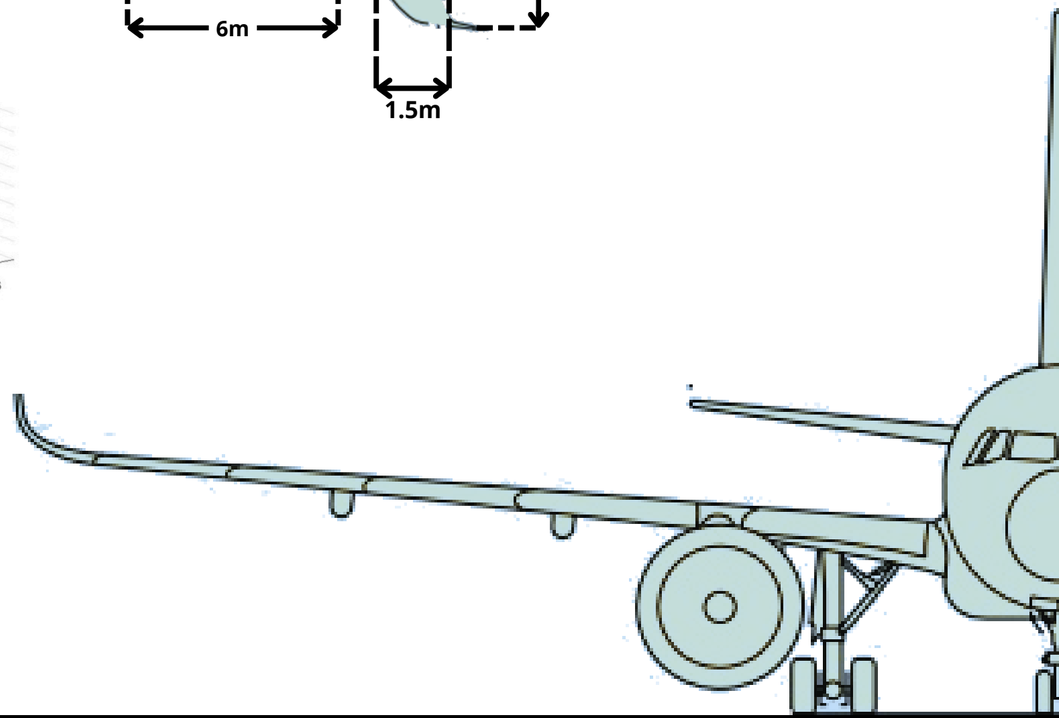
MODELO DE ALA DE UN A320

MODELADO

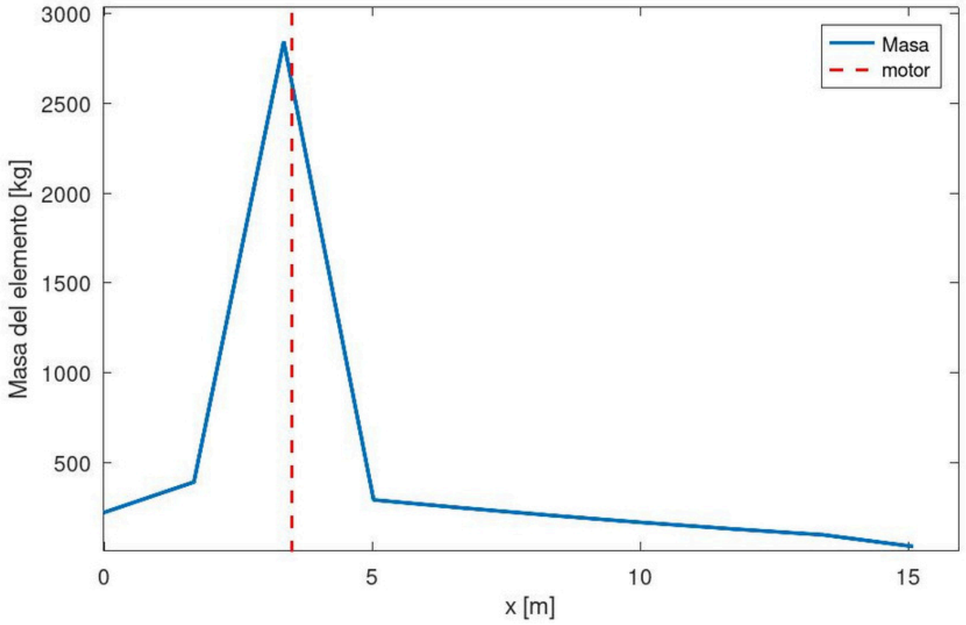


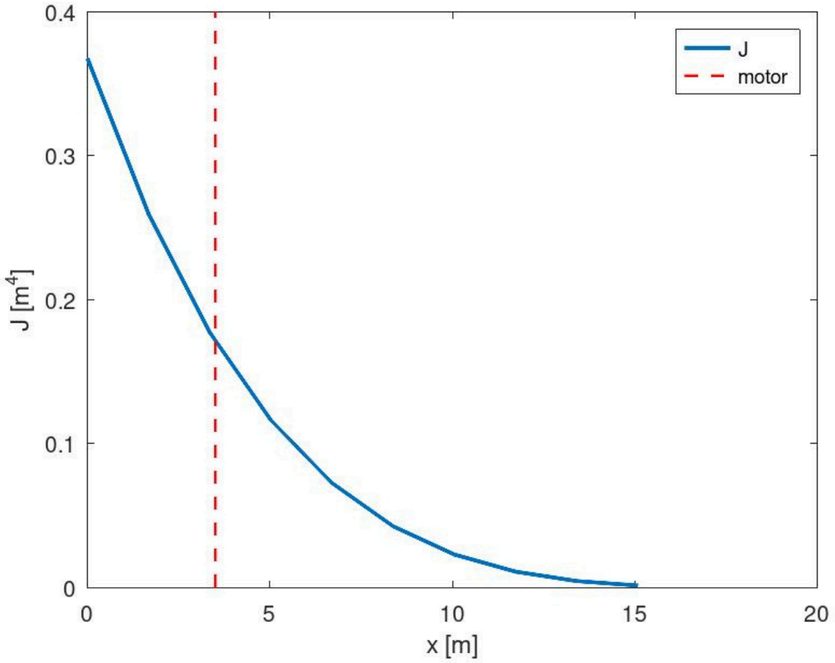


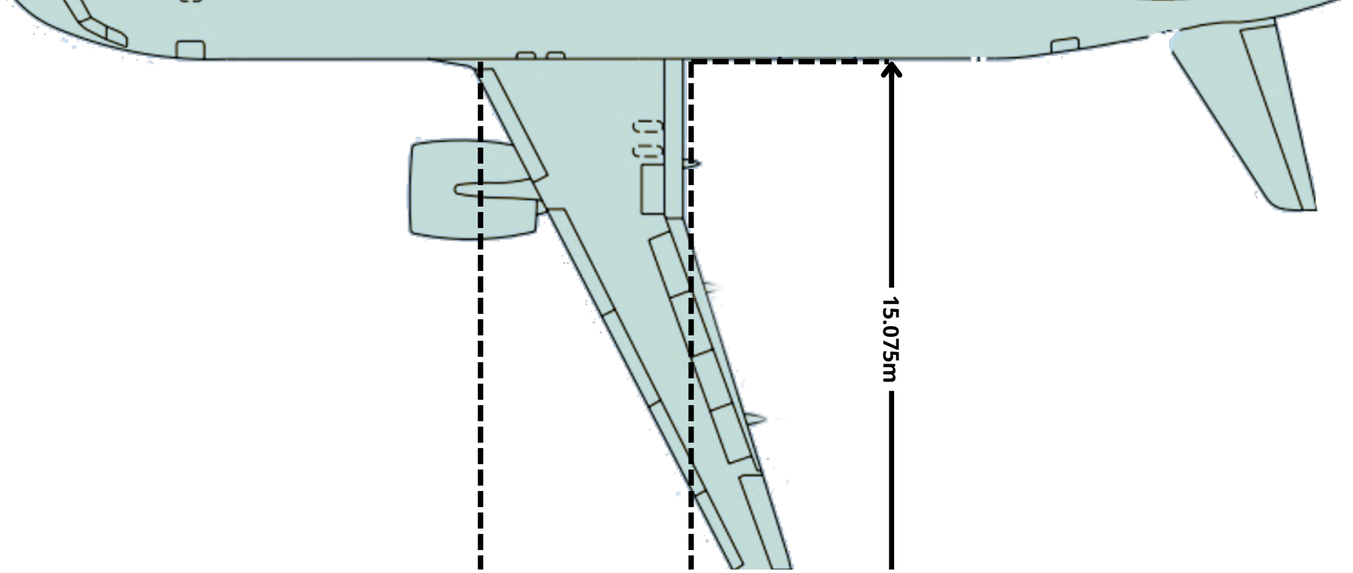


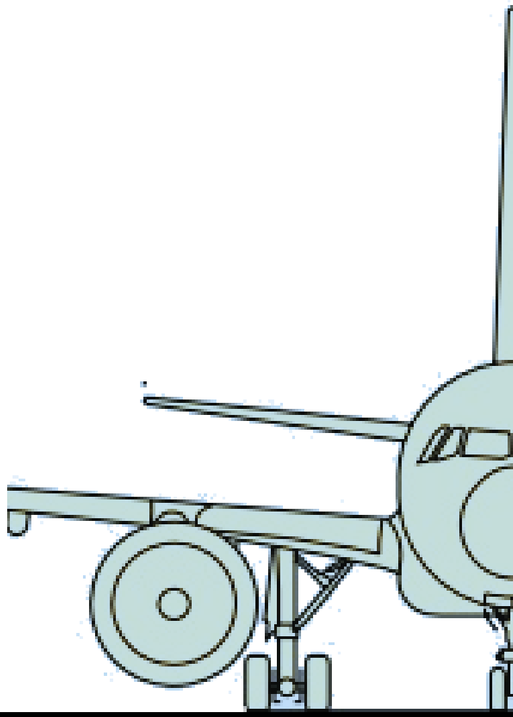


MODELADO

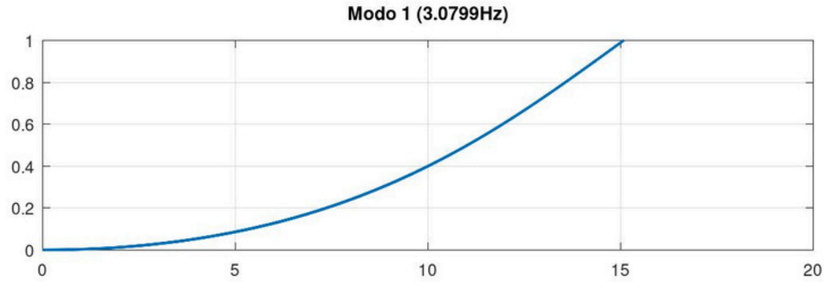

Masa
motor
Masa del elemento [kg]
x [m]
3000
2500
2000
1500
1000
500
0
5
10
15

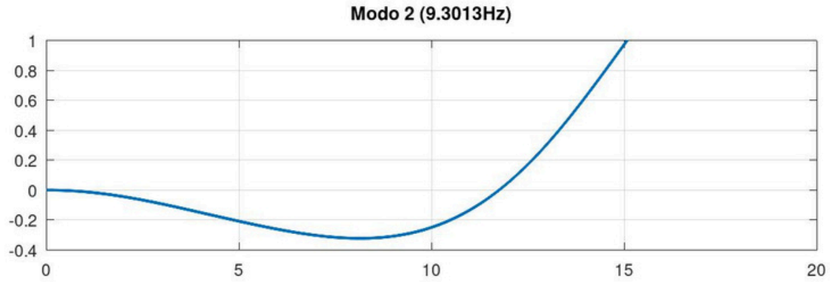

J
motor
J [m^4]
x [m]
0.4
0.3
0.2
0.1
0
0
5
10
15
20

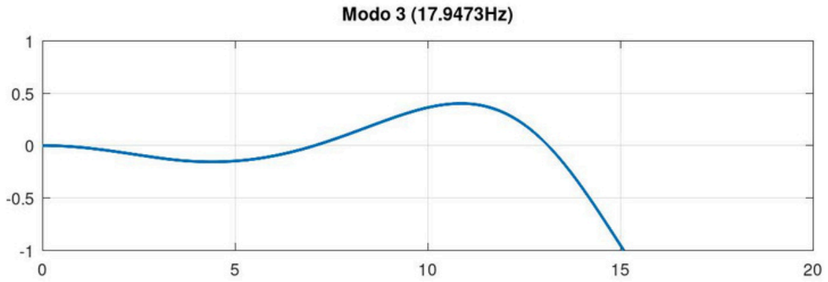

15.075m

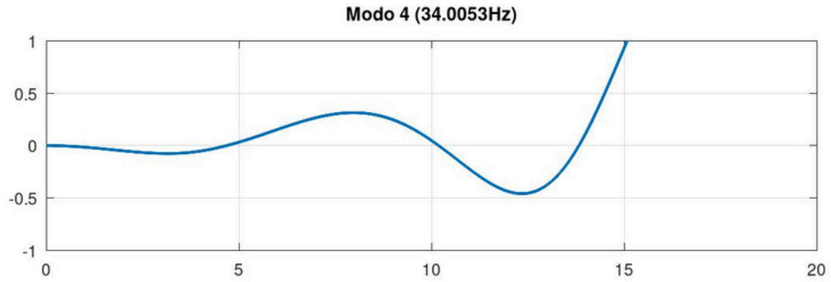


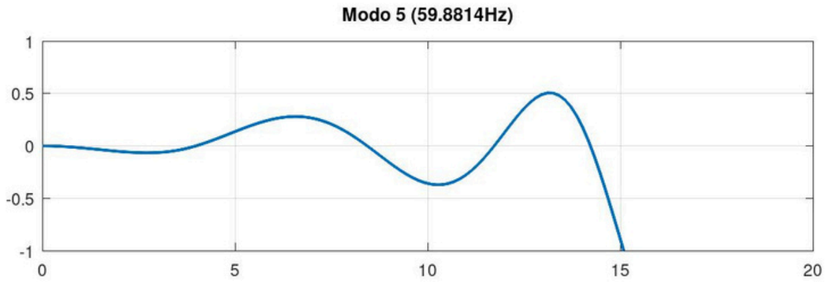
RESULTADOS

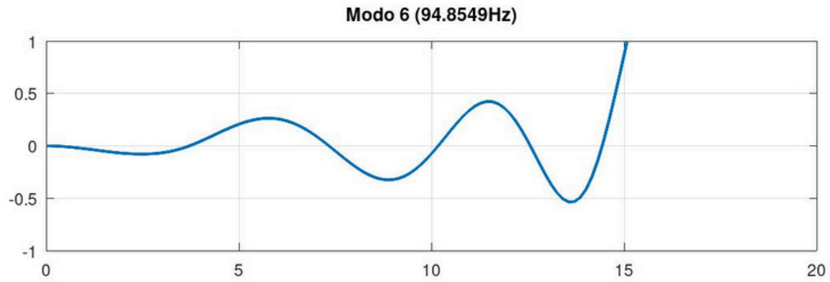

Modo 1 (3.0799Hz)
1
0.8
0.6
0.4
0.2
0
0
5
10
15
20


Modo 2 (9.3013Hz)
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
0
5
10
15
20


Modo 3 (17.9473Hz)
1
0.5
0
-0.5
-1
0
5
10
15
20


Modo 4 (34.0053Hz)
1
0.5
0
-0.5
-1
0
5
10
15
20


Modo 5 (59.8814Hz)
1
0.5
0
-0.5
-1
0
5
10
15
20


Modo 6 (94.8549Hz)
1
0.5
0
-0.5
-1
0
5
10
15
20

GRACIAS POR ESCUCHAR

Todo el codigo disponible en:

github.com/SantiColu/dynamic-systems