



Facultad de  
Ingeniería  
UNLP



# ANÁLISIS DINÁMICO AIRBUS A320

Sistemas Dinamicos - Modulo 1 - 2025

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POR:

Santiago Colusso



# TABLA DE CONTENIDO

A1

**Análisis de la dinámica natural con un  
modelo de cuerpo rígido**

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Modelo lineal

---

Resultados

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Comparacion

A2

**Modelo de deformacion a flexion de las alas**

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Parametros distribuidos

---

Parametros concentrados

---

Modelo del ala

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Resultados



# DINAMICA NATURAL DE UN CUERPO RIGIDO

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

# MODELO LINEAL

---

$$\dot{x} = f(x, u) \approx f(\bar{x}, \bar{u}) + \frac{\partial f}{\partial x}\Big|_{\bar{x}, \bar{u}} (x - \bar{x}) + \frac{\partial f}{\partial u}\Big|_{\bar{x}, \bar{u}} (u - \bar{u}) + \dots$$

$$\begin{aligned} \mathbf{A} &= \frac{\partial f}{\partial x}\Big|_{\bar{x}, \bar{u}}, \quad \Delta x = x - \bar{x} \\ \mathbf{B} &= \frac{\partial f}{\partial u}\Big|_{\bar{x}, \bar{u}}, \quad \Delta u = u - \bar{u} \end{aligned}$$



$$\dot{x} = \mathbf{A}x + \mathbf{B}u$$



$$\mathbf{A}v_j = \lambda_j v_j$$

$$\lambda_j$$

evolucion temporal de  
la amplitud de x

$$v_j$$

direccion en el espacio  
de estados

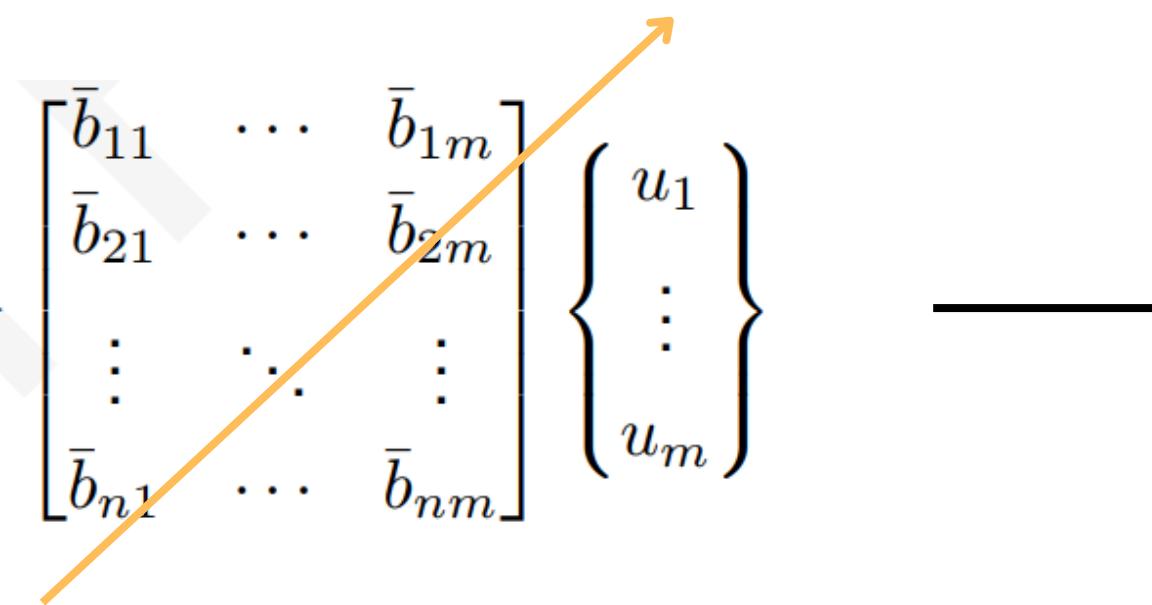
# COORDENADAS MODALES

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$$\Lambda = [v_1 \ v_2 \ \cdots \ v_n]$$

↓

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

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


$\Rightarrow$   $z_j(t) = z_j(0)e^{\lambda_j t}$   $\longrightarrow$   $x_i(t) = v_{1i}z_1(t) + v_{2i}z_2(t) + \cdots + v_{ni}z_n(t)$

# 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));

% lat:
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

---

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

# MODELO LINEAL

---

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

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

# MODELO LINEAL

---

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

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

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

# MODELO LINEAL

---

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

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

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

# MODELO LINEAL

---

**A<sub>lat</sub>** =

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

# 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

---

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

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

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

# MODELO LINEAL

---

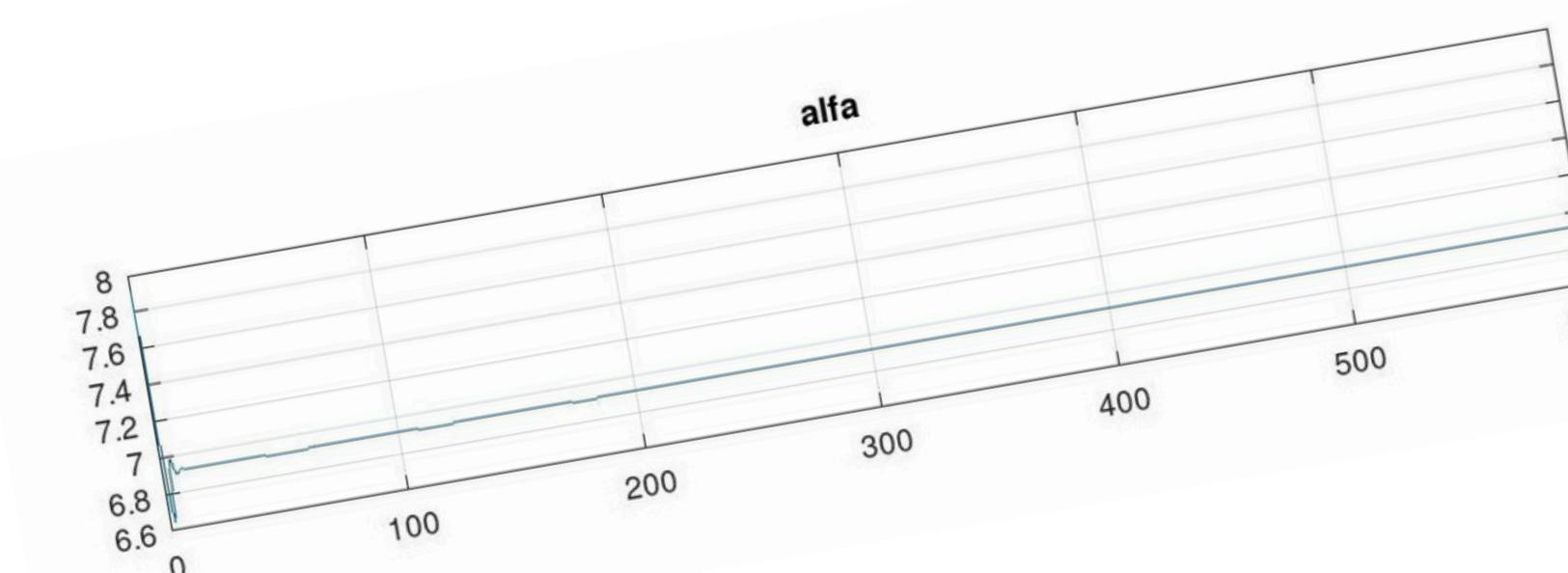
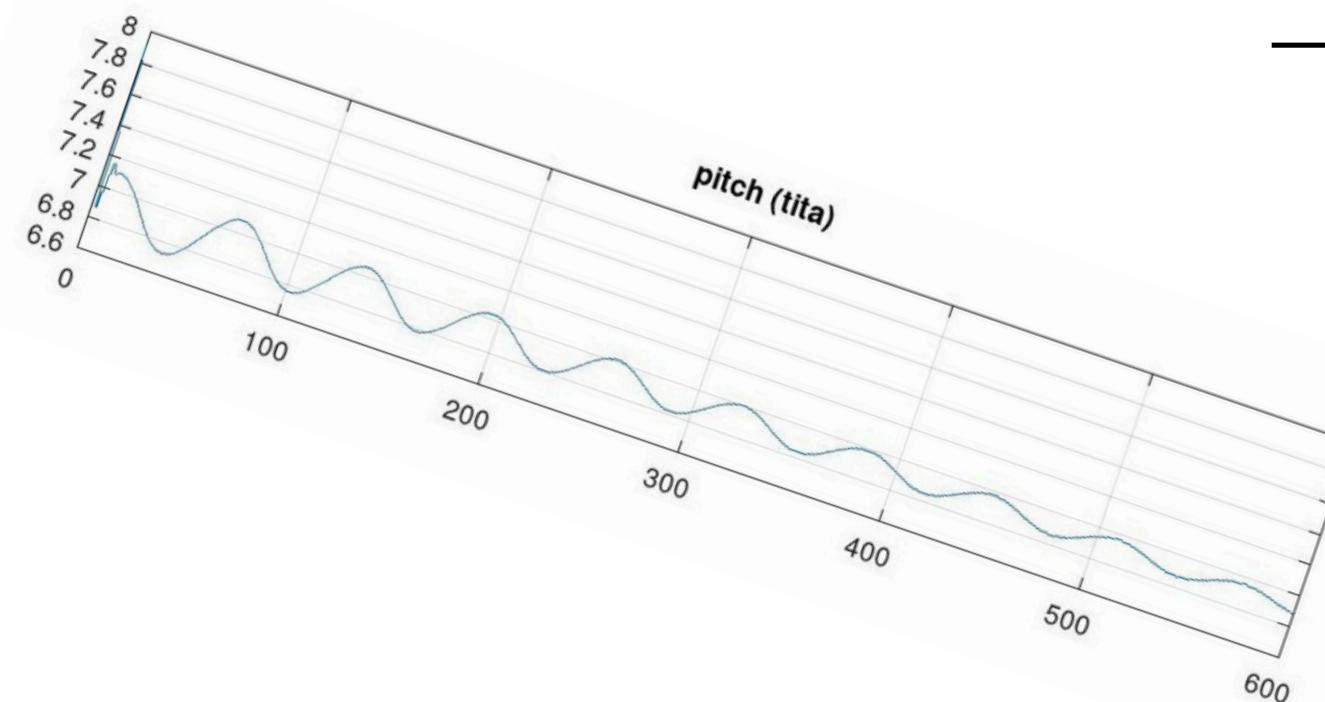
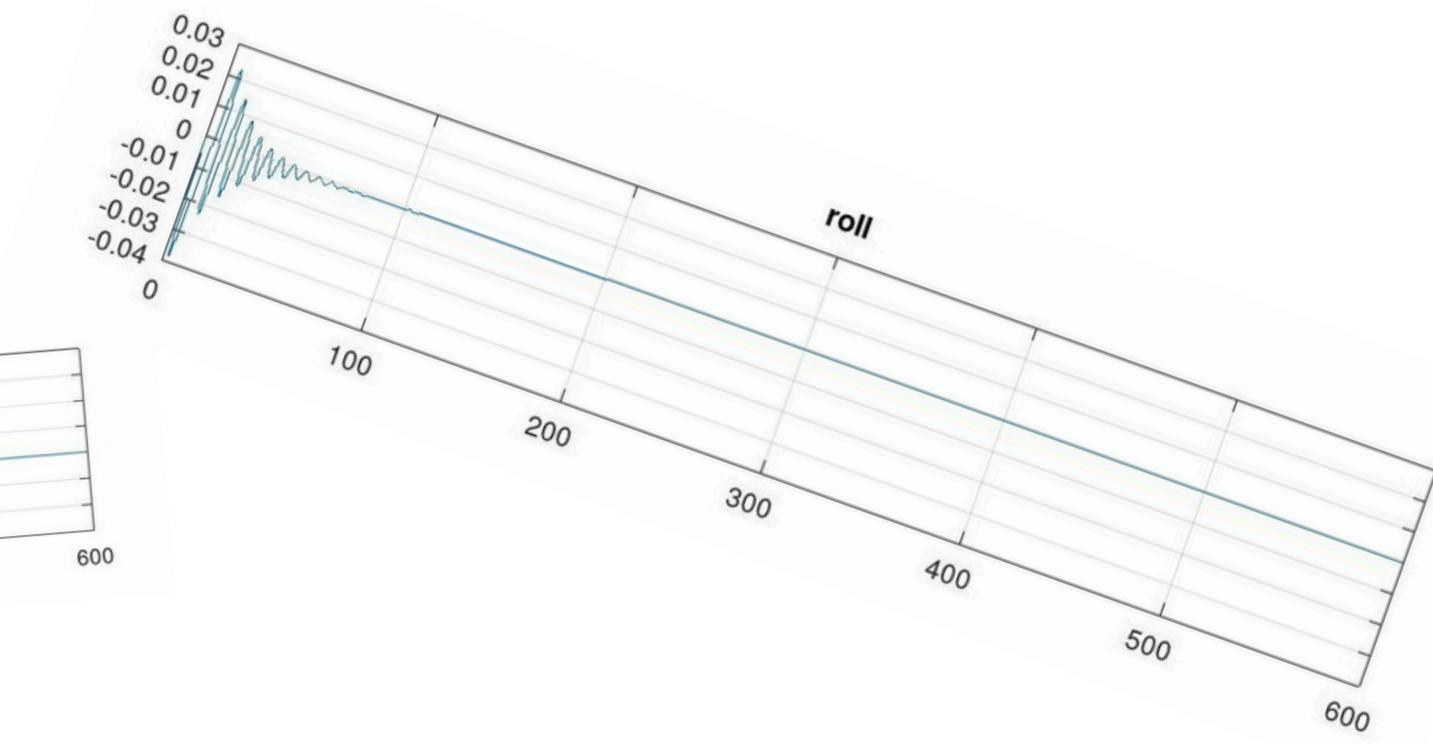
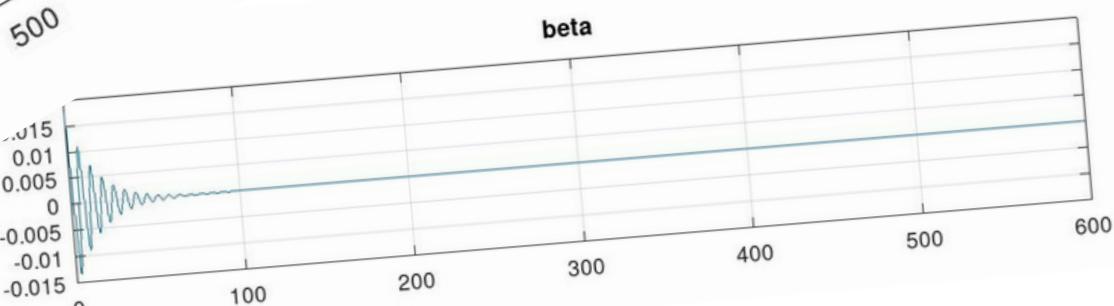
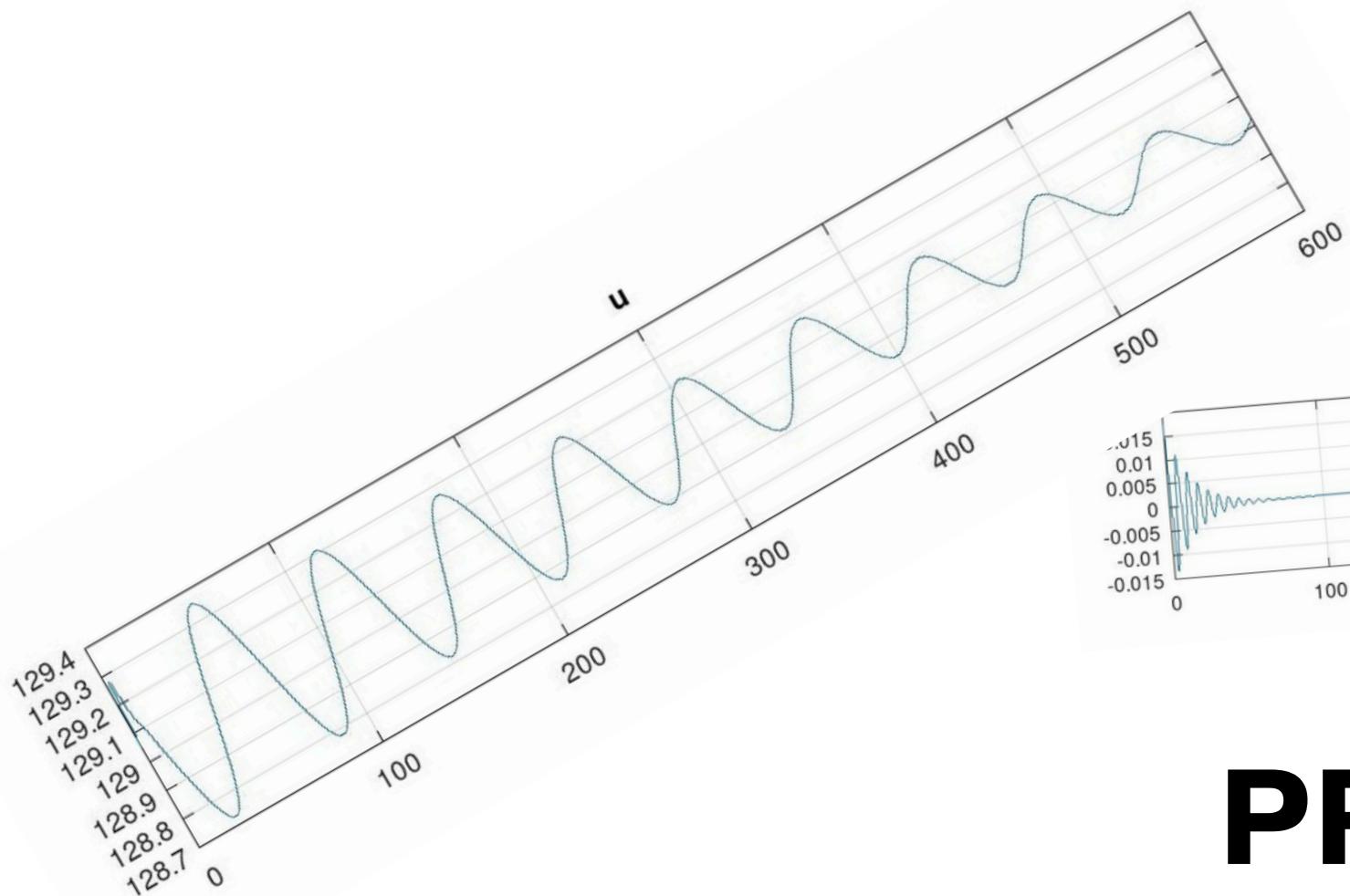
$$A_{\text{lat}} = \begin{bmatrix} -0.0894 & 0.1202 & -0.9927 & 0.0749 \\ -2.5220 & -0.6859 & 0.4045 & 0 \\ 0.5670 & -0.0649 & -0.1542 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix}$$

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

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

# PRIMEROS RESULTADOS

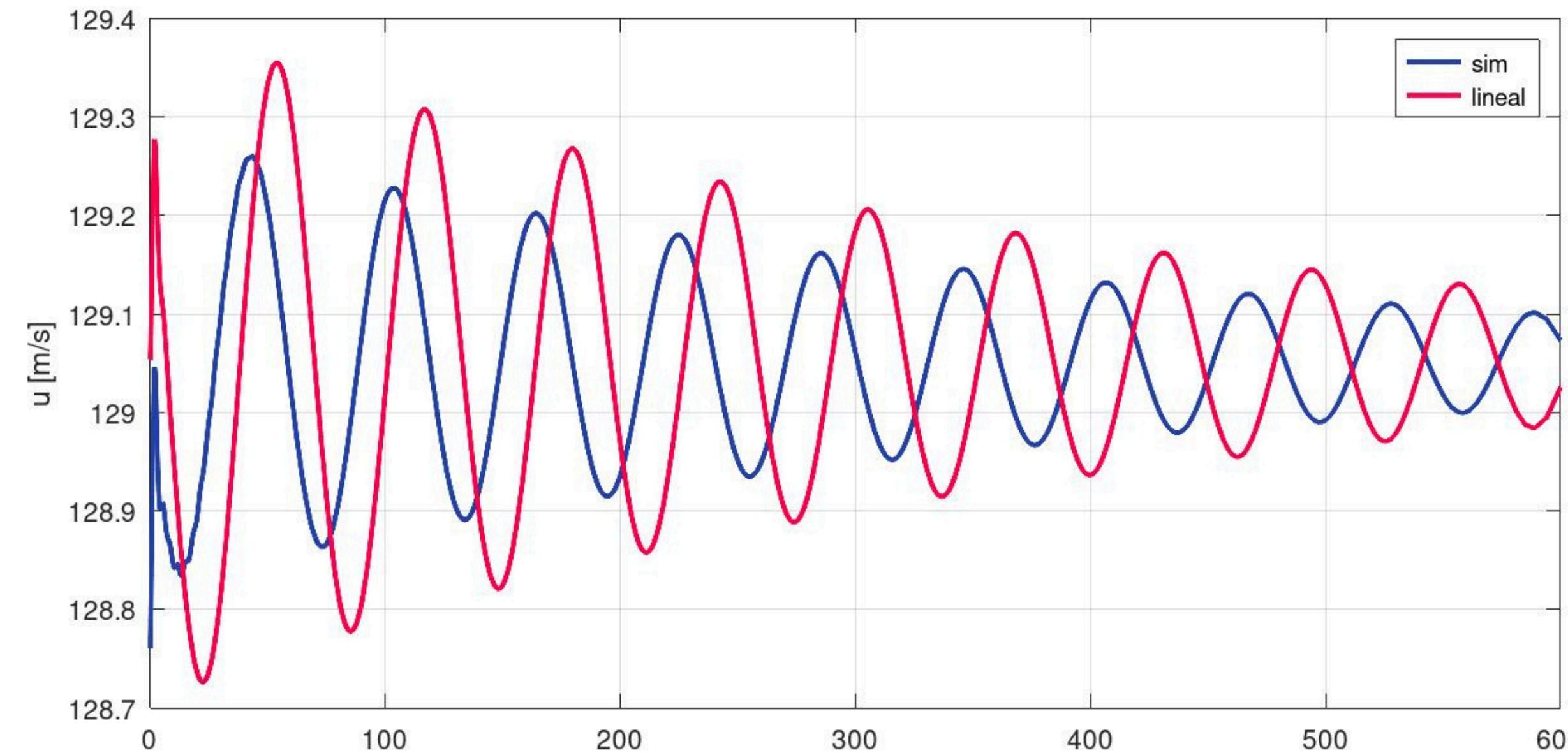
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# PRIMEROS RESULTADOS

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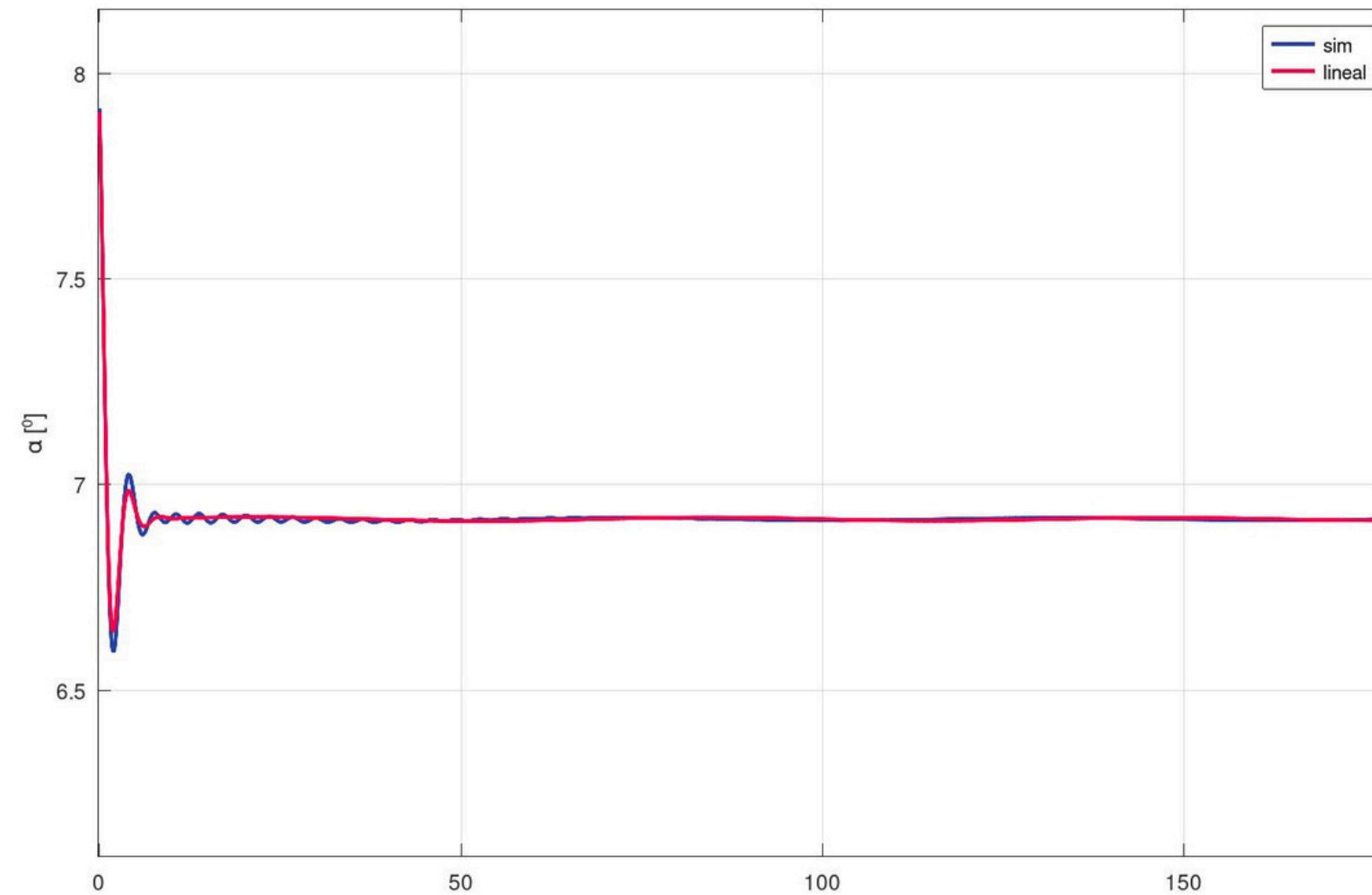
Velocidad (u)



# PRIMEROS RESULTADOS

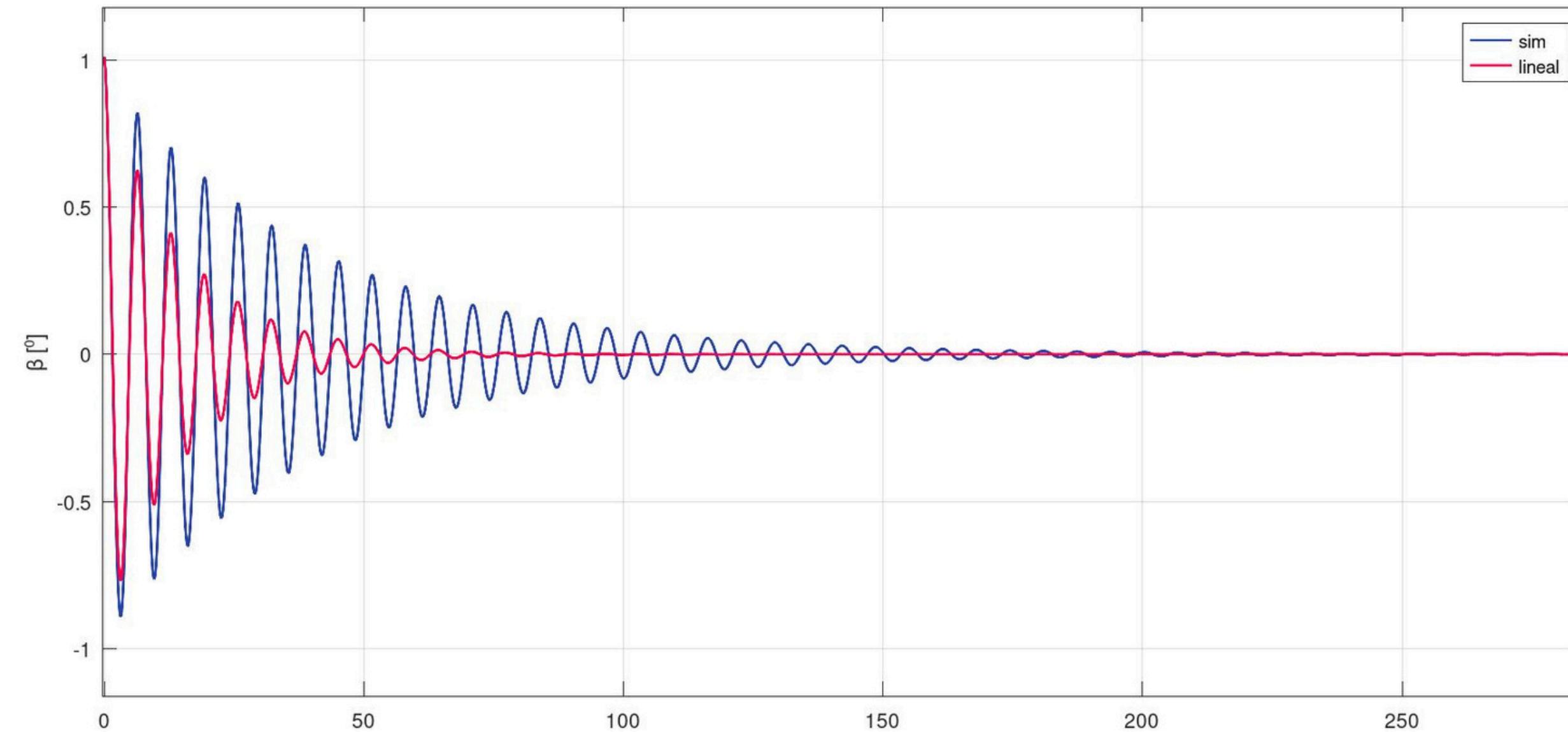
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Angulo de ataque ( $\alpha$ )



# PRIMEROS RESULTADOS

Angulo de deslizamiento ( $\beta$ )

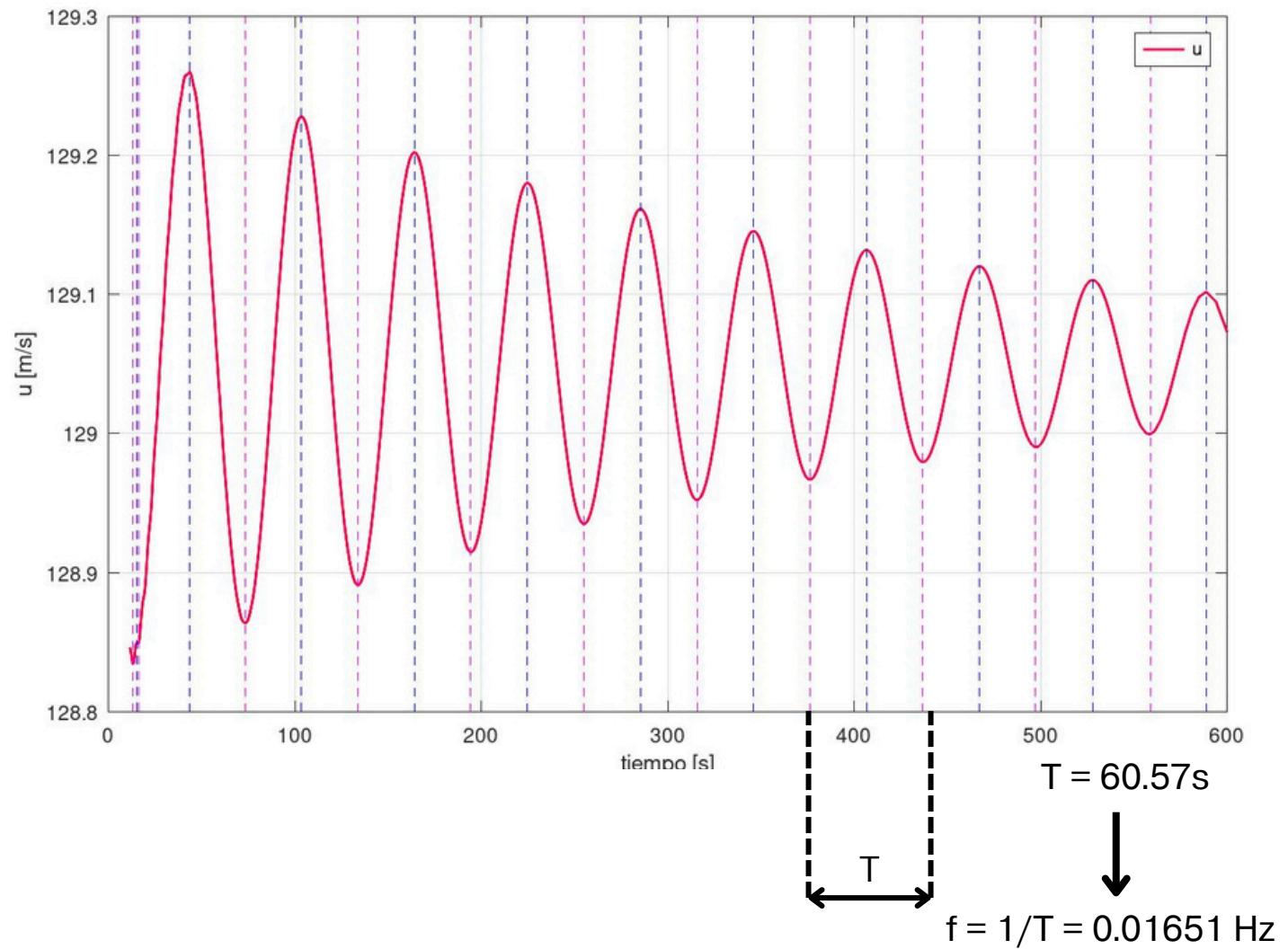


# **ANALISIS DE MODOS**

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# ANALISIS LONG MODO LENTO

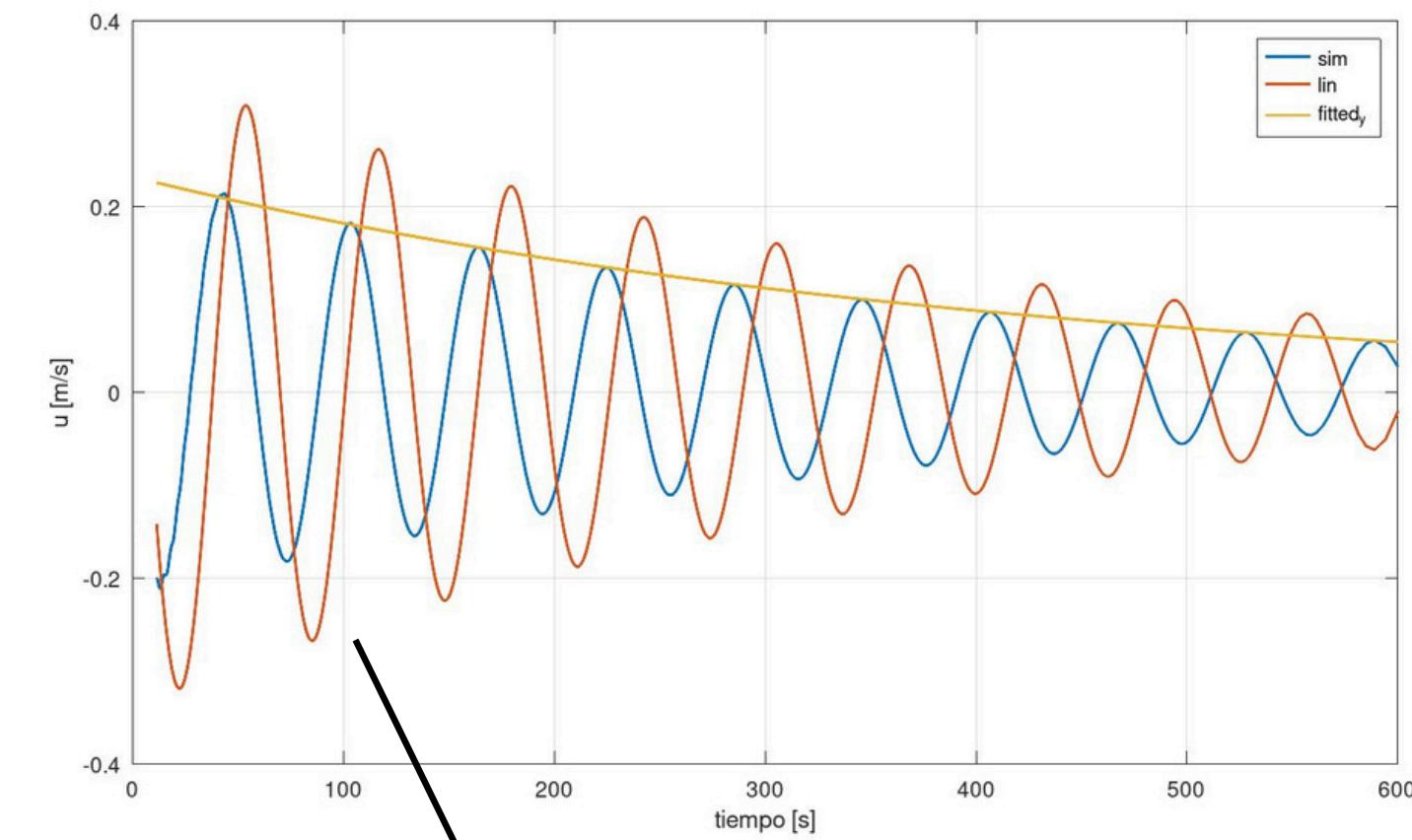
$\Delta\alpha = 1^\circ$



$$D_{\text{long}} =$$

$$\begin{bmatrix} -0.633145 + 1.464589i \\ -0.633145 - 1.464589i \\ \boxed{-0.002716 + 0.099902i} \\ \boxed{-0.002716 - 0.099902i} \end{bmatrix}$$

$$\left. \begin{array}{l} f = \omega/2\pi = \text{im}(D_3)/2\pi = 0.0159 \text{ Hz} \\ \text{amort} = \text{re}(D_3) = -0.002716 \end{array} \right\}$$



$$\text{fit} = \gamma e^{\lambda t} \quad \lambda = -0.002605$$

# ANALISIS LONG MODO LENTO

---

## Condiciones de vuelo:

$$h = 5000\text{m}$$

$$v = 130\text{m/s}$$

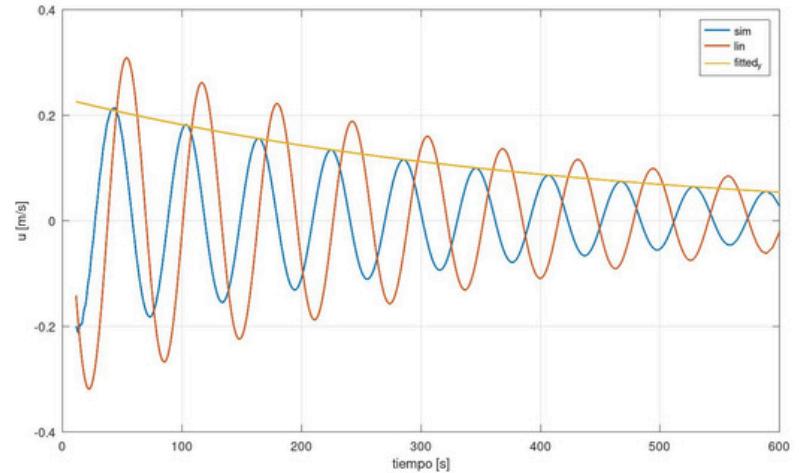
$$\beta = 0^\circ$$

$$\text{AoA} = 6.91^\circ$$

$$\gamma = 0^\circ$$

$$\text{roll} = 0^\circ$$

$$\Delta\alpha = 1^\circ$$



$$\begin{cases} f_{\text{real}} = 0.016509 \text{ Hz} \\ f_{\text{lineal}} = 0.0159 \text{ Hz} \end{cases}$$



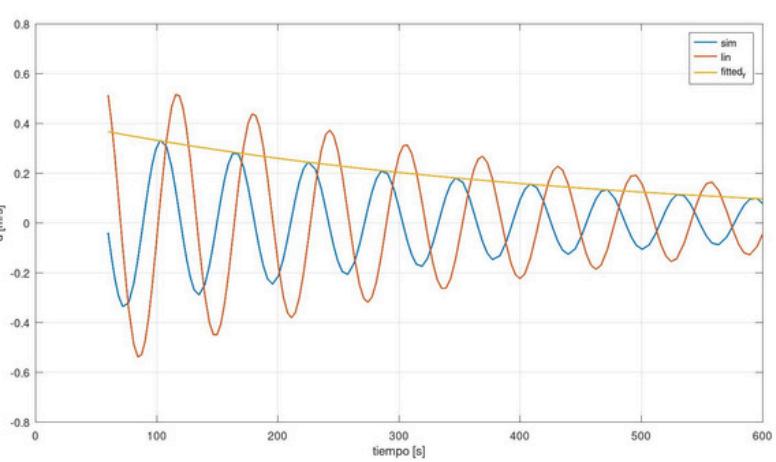
error: 3.7%

$$\begin{cases} am_{\text{real}} = -0.002605 \\ am_{\text{lineal}} = -0.002716 \end{cases}$$



error: 4.3%

$$\Delta\alpha = 2^\circ$$



$$\begin{cases} f_{\text{real}} = 0.01668 \text{ Hz} \\ f_{\text{lineal}} = 0.0159 \text{ Hz} \end{cases}$$



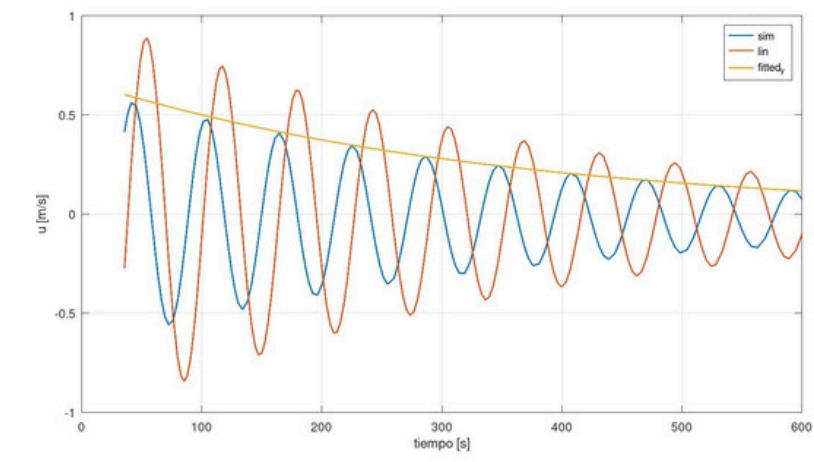
error: 4.7%

$$\begin{cases} am_{\text{real}} = -0.002462 \\ am_{\text{lineal}} = -0.002716 \end{cases}$$



error: 10.3%

$$\Delta\alpha = 3^\circ$$



$$\begin{cases} f_{\text{real}} = 0.015735 \text{ Hz} \\ f_{\text{lineal}} = 0.0159 \text{ Hz} \end{cases}$$



error: 1%

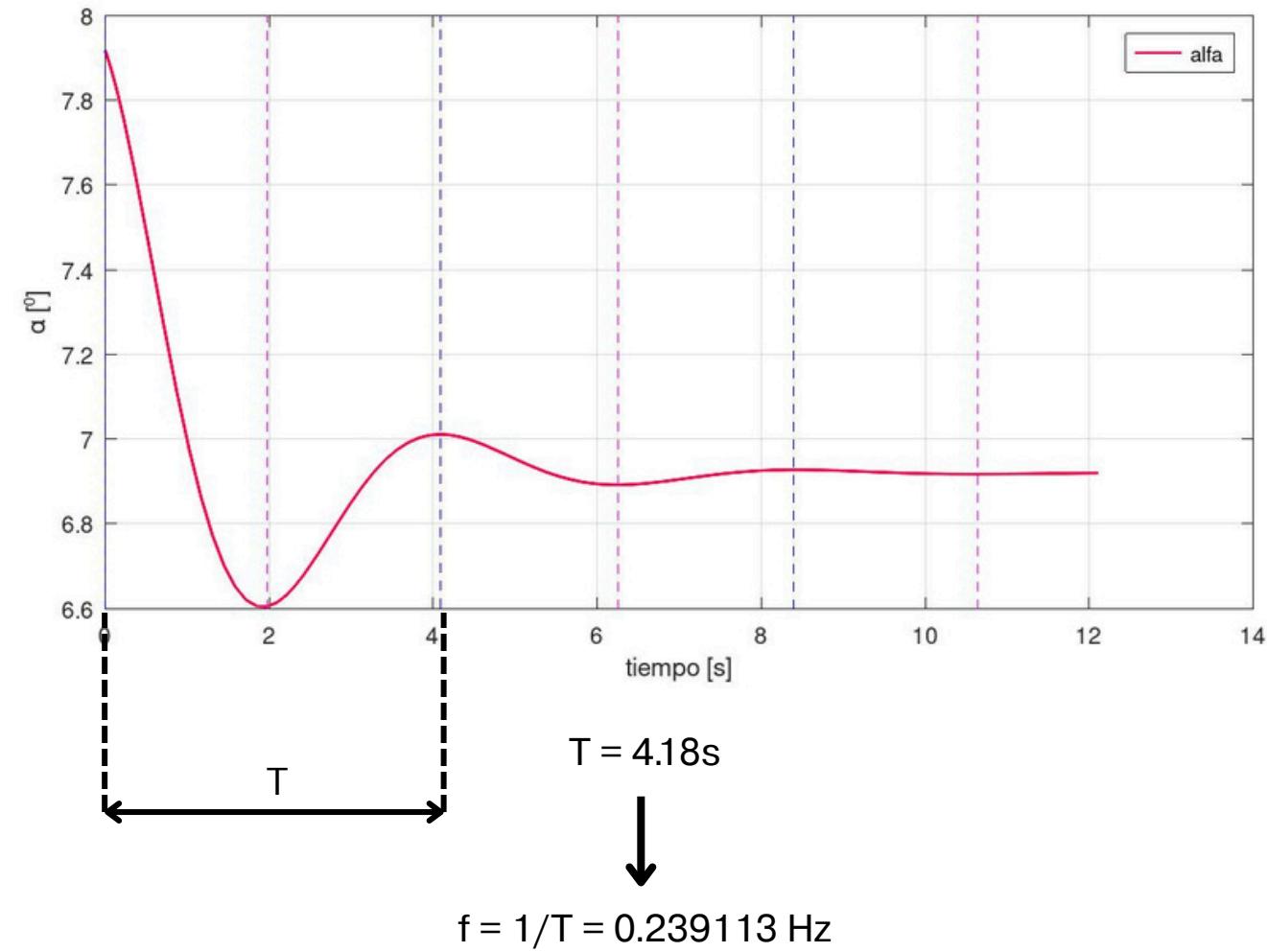
$$\begin{cases} am_{\text{real}} = -0.002912 \\ am_{\text{lineal}} = -0.002716 \end{cases}$$



error: 6.7%

# ANALISIS LONG MODO RAPIDO

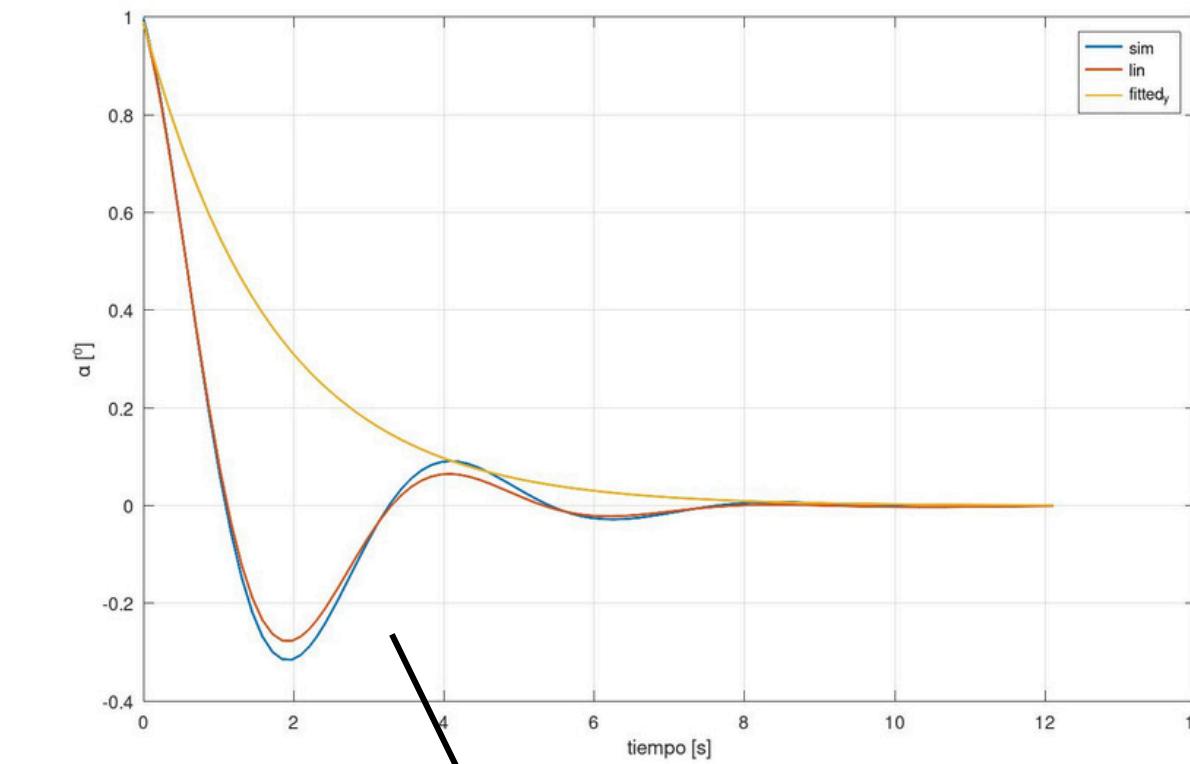
$$\Delta\alpha = 1^\circ$$



$$D_{\text{long}} =$$

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

$$\left. \begin{aligned} f &= \omega/2\pi = \text{im}(D_1)/2\pi = 0.2331 \text{ Hz} \\ \text{amort} &= \text{re}(D_1) = -0.633145 \end{aligned} \right\}$$



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

# ANALISIS LONG MODO RAPIDO

---

## Condiciones de vuelo:

$$h = 5000\text{m}$$

$$v = 130\text{m/s}$$

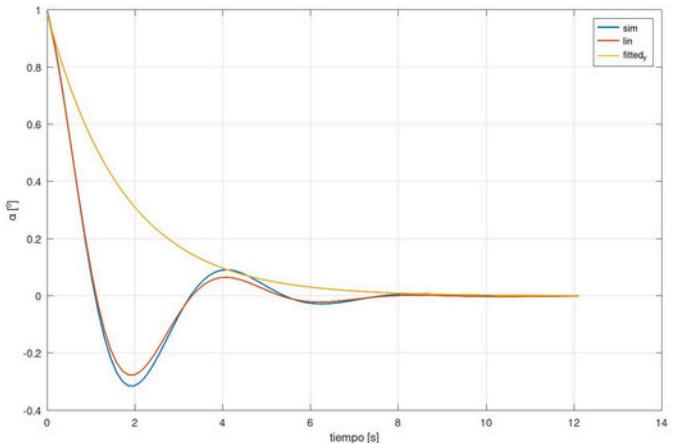
$$\beta = 0^\circ$$

$$\text{AoA} = 6.91^\circ$$

$$\gamma = 0^\circ$$

$$\text{roll} = 0^\circ$$

$$\Delta\alpha = 1^\circ$$



$$\begin{cases} f_{\text{real}} = 0.239113 \text{ Hz} \\ f_{\text{lineal}} = 0.2331 \text{ Hz} \end{cases}$$



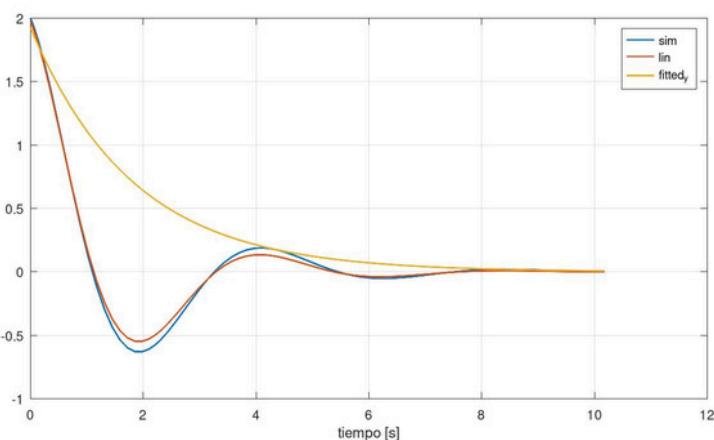
error: 2.5%

$$\begin{cases} am_{\text{real}} = -0.580791 \\ am_{\text{lineal}} = -0.633145 \end{cases}$$



error: 9.0%

$$\Delta\alpha = 2^\circ$$



$$\begin{cases} f_{\text{real}} = 0.238361 \text{ Hz} \\ f_{\text{lineal}} = 0.2331 \text{ Hz} \end{cases}$$



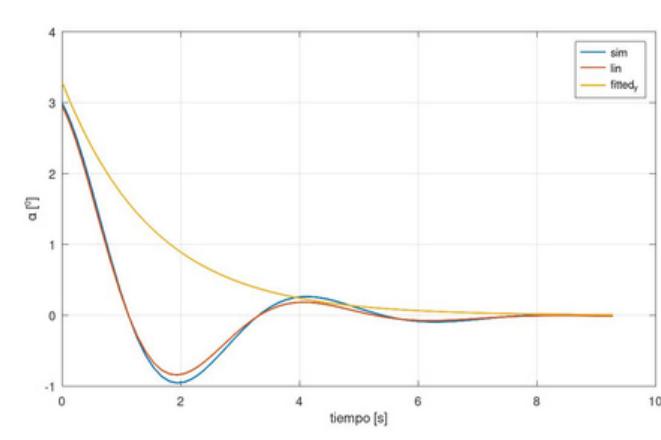
error: 2.2%

$$\begin{cases} am_{\text{real}} = -0.551022 \\ am_{\text{lineal}} = -0.633145 \end{cases}$$



error: 14.9%

$$\Delta\alpha = 3^\circ$$



$$\begin{cases} f_{\text{real}} = 0.233881 \text{ Hz} \\ f_{\text{lineal}} = 0.2331 \text{ Hz} \end{cases}$$



error: 0.3%

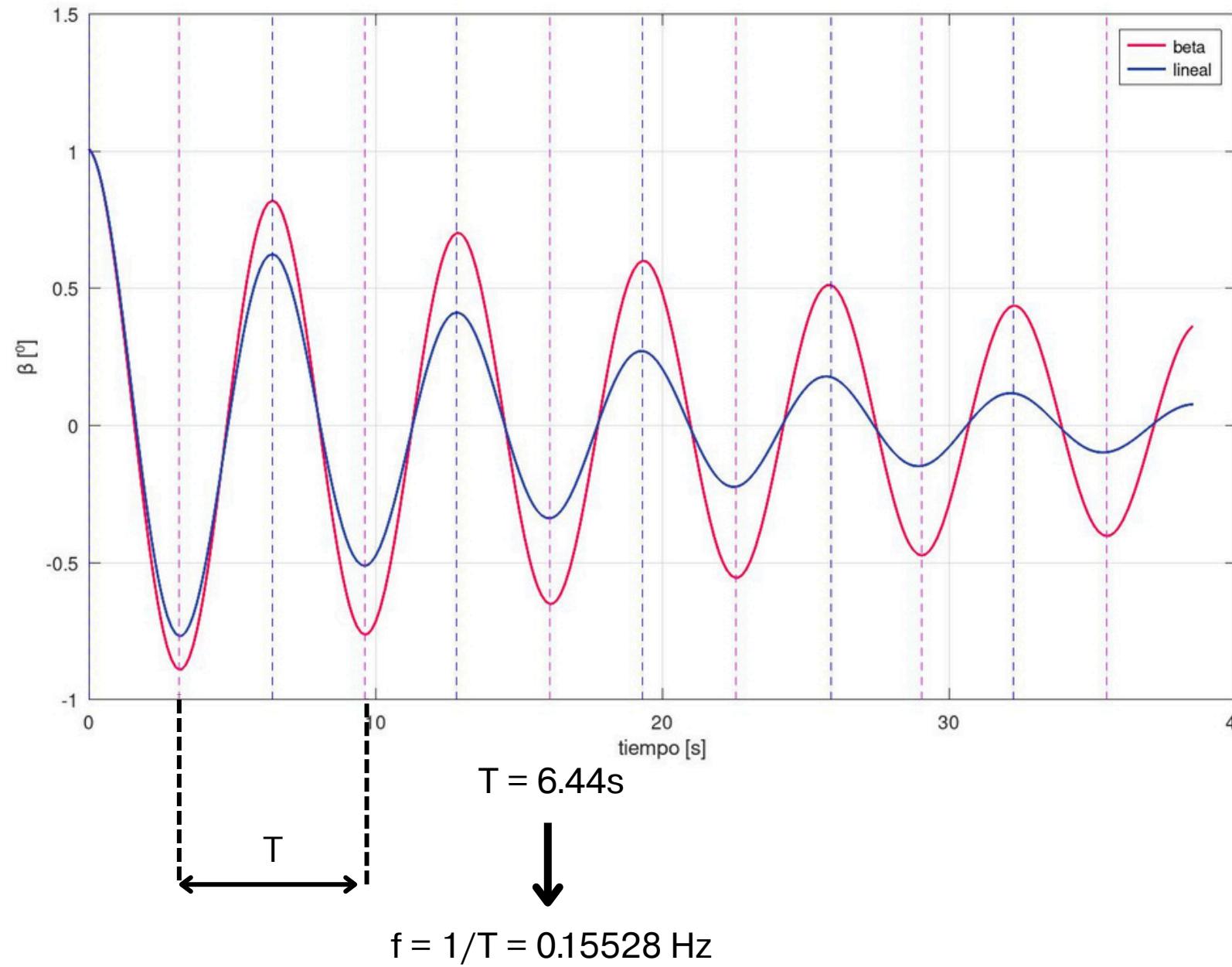
$$\begin{cases} am_{\text{real}} = -0.653547 \\ am_{\text{lineal}} = -0.633145 \end{cases}$$



error: 3.1%

# ANALISIS LAT

$$\Delta\beta = 1^\circ$$



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

A green arrow points from the text  $f = \omega/2\pi = \text{im}(D_1)/2\pi = 0.15541\text{ Hz}$  to the second row of the matrix.

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

# ANALISIS LAT

---

## Condiciones de vuelo:

$$h = 5000\text{m}$$

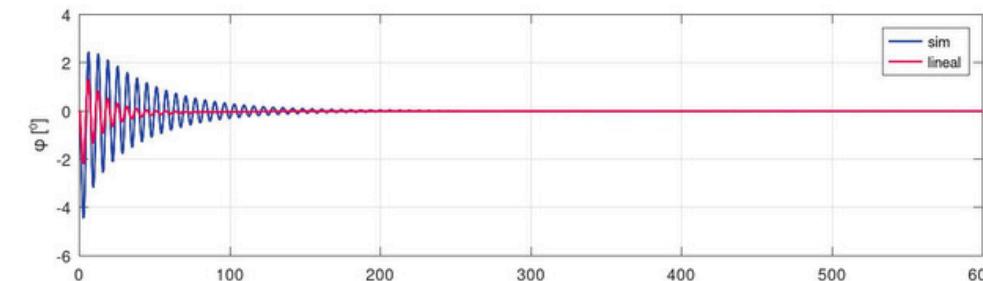
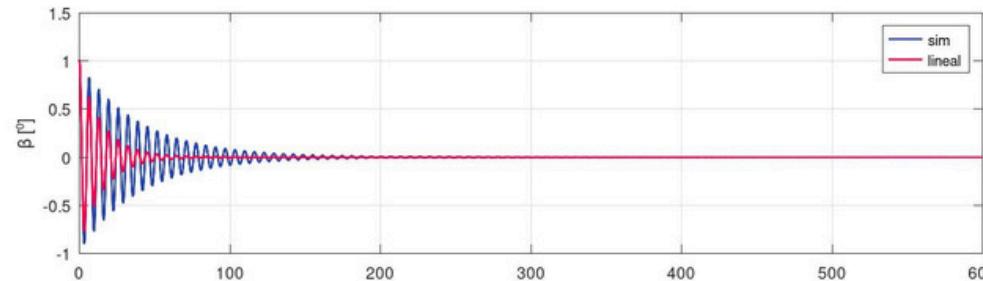
$$v = 130\text{m/s}$$

$$\text{AoA} = 6.91^\circ$$

$$\gamma = 0^\circ$$

$$\Delta\beta = 1^\circ$$

$$\Delta\varphi = 0^\circ$$



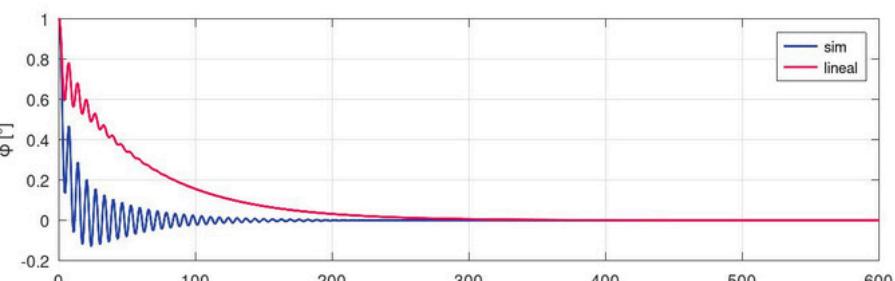
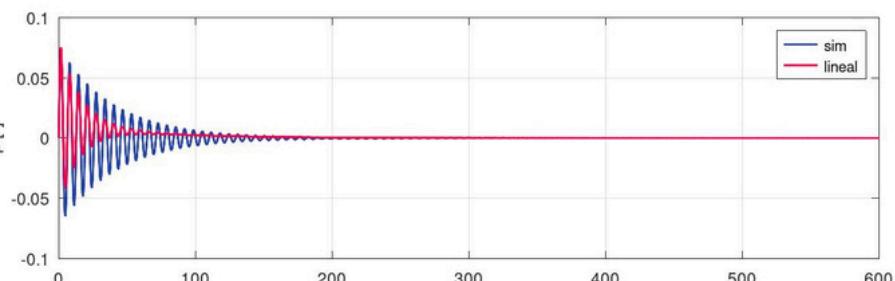
$$\begin{cases} f_{\text{real}} = 0.156084 \text{ Hz} \\ f_{\text{lineal}} = 0.155407 \text{ Hz} \end{cases}$$



error: 0.4%

$$\Delta\beta = 0^\circ$$

$$\Delta\varphi = 1^\circ$$



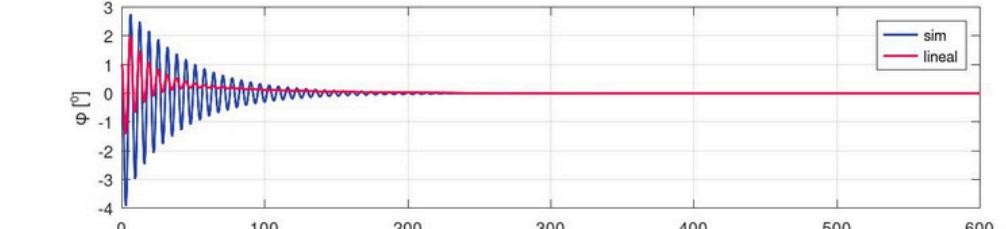
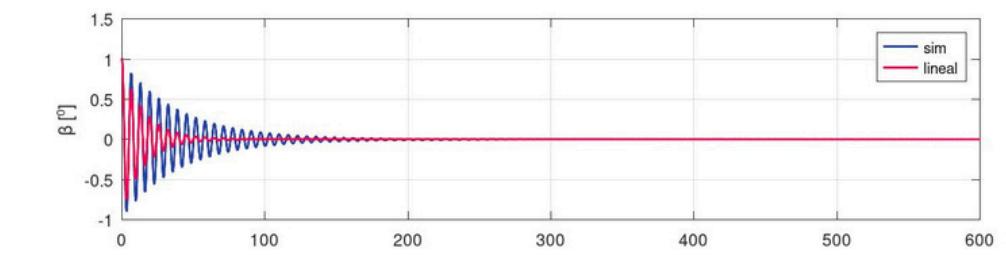
$$\begin{cases} f_{\text{real}} = 0.178618 \text{ Hz} \\ f_{\text{lineal}} = 0.155407 \text{ Hz} \end{cases}$$



error: 13.0%

$$\Delta\beta = 1^\circ$$

$$\Delta\varphi = 1^\circ$$



$$\begin{cases} f_{\text{real}} = 0.153937 \text{ Hz} \\ f_{\text{lineal}} = 0.155407 \text{ Hz} \end{cases}$$



error: 1.0%

# COMPUESTO

## Condiciones de vuelo:

$h = 5000\text{m}$

$v = 130\text{m/s}$

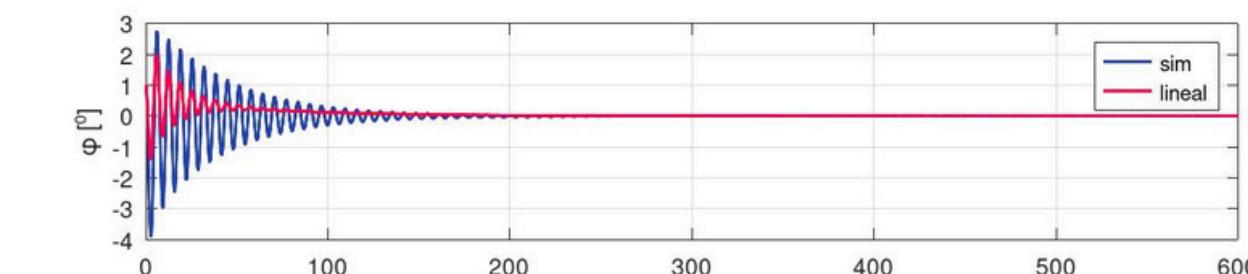
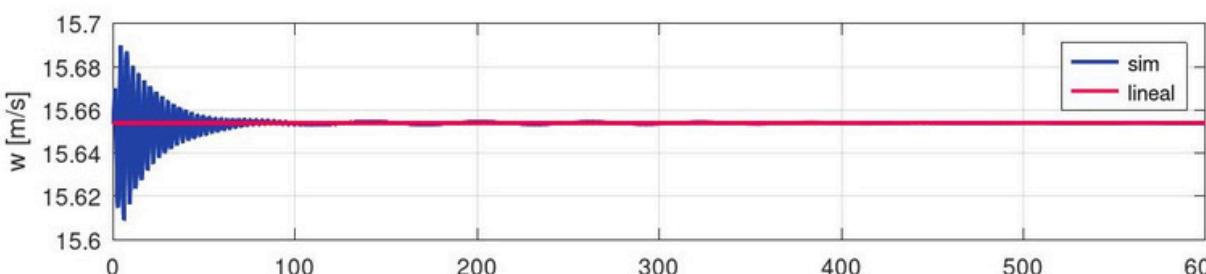
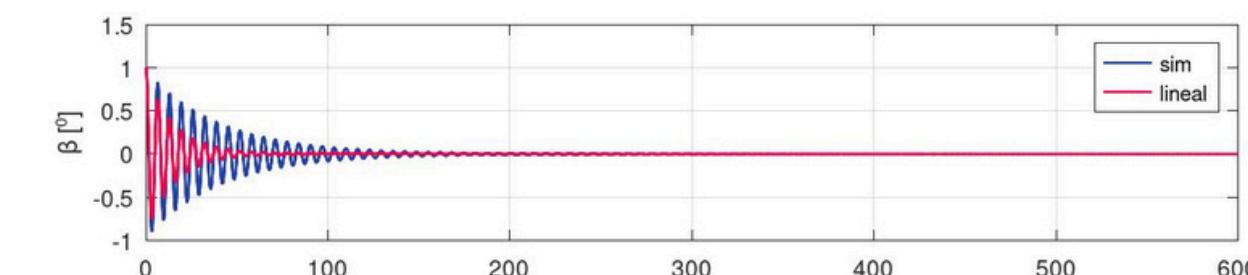
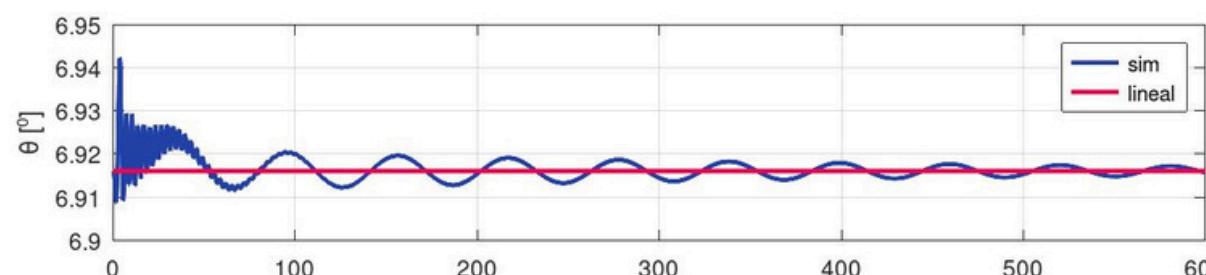
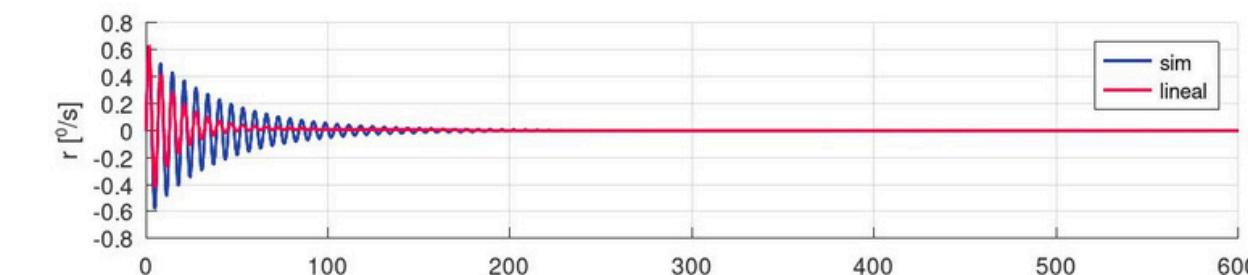
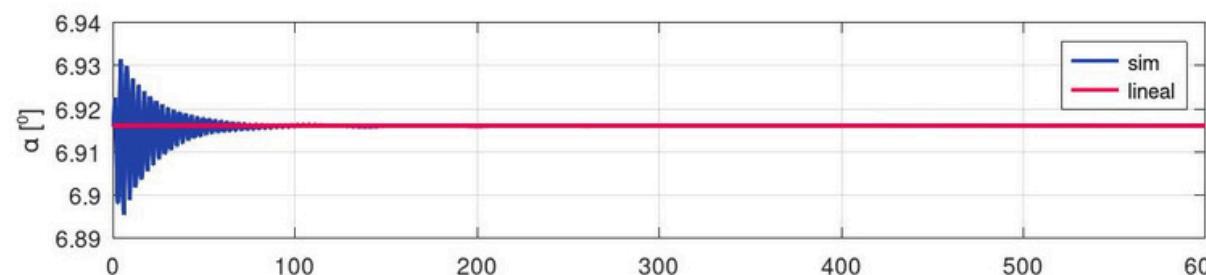
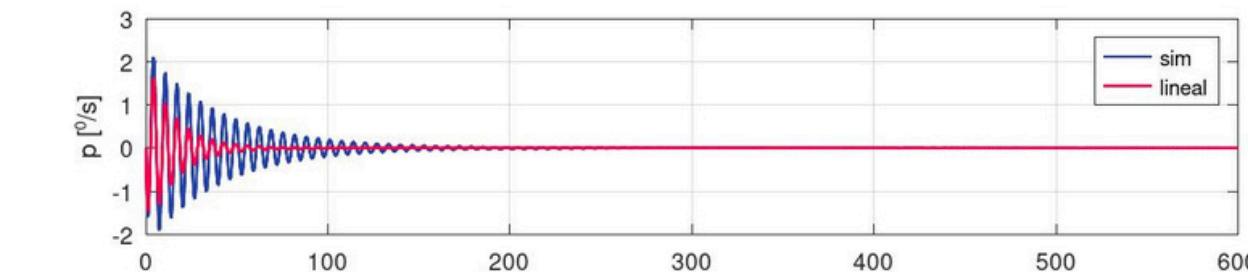
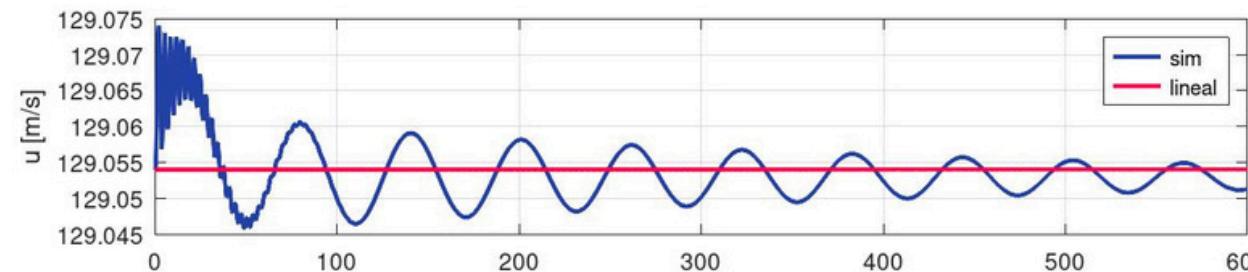
$\text{AoA} = 6.91^\circ$

$\gamma = 0^\circ$

$\Delta\alpha = 0^\circ$

$\Delta\beta = 1^\circ$

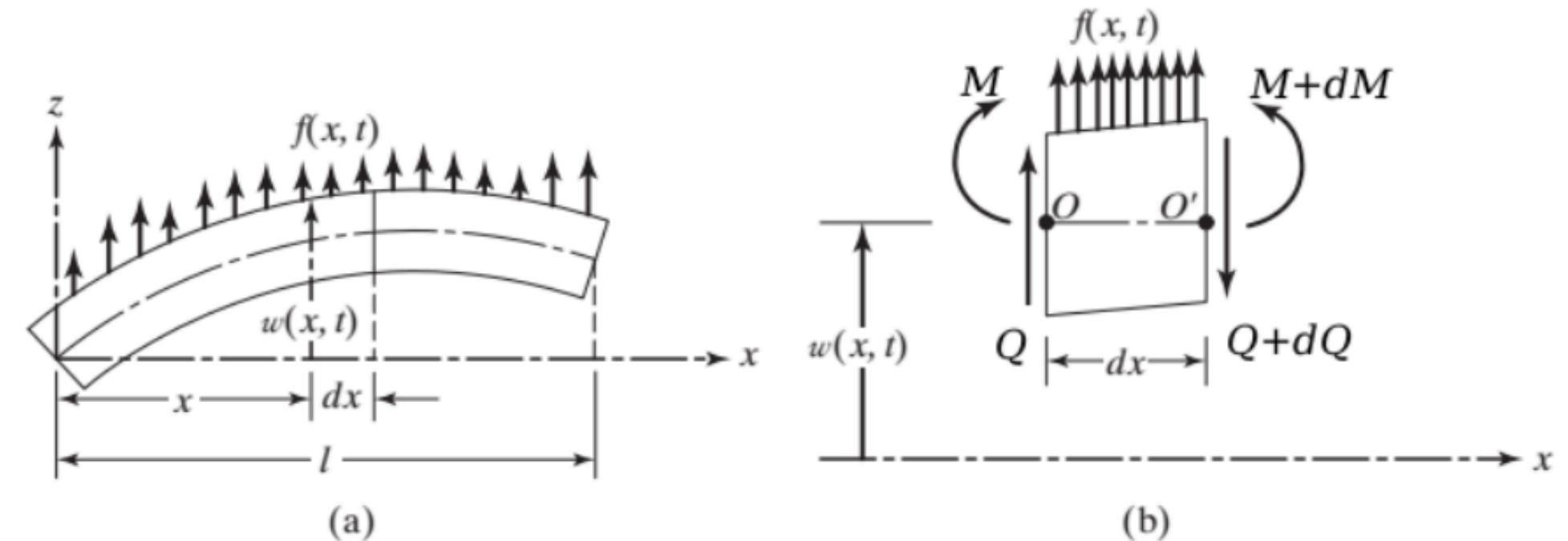
$\Delta\varphi = 1^\circ$





# DEFORMACION DE ALAS A FLEXION

# PARAMETROS DISTRIBUIDOS



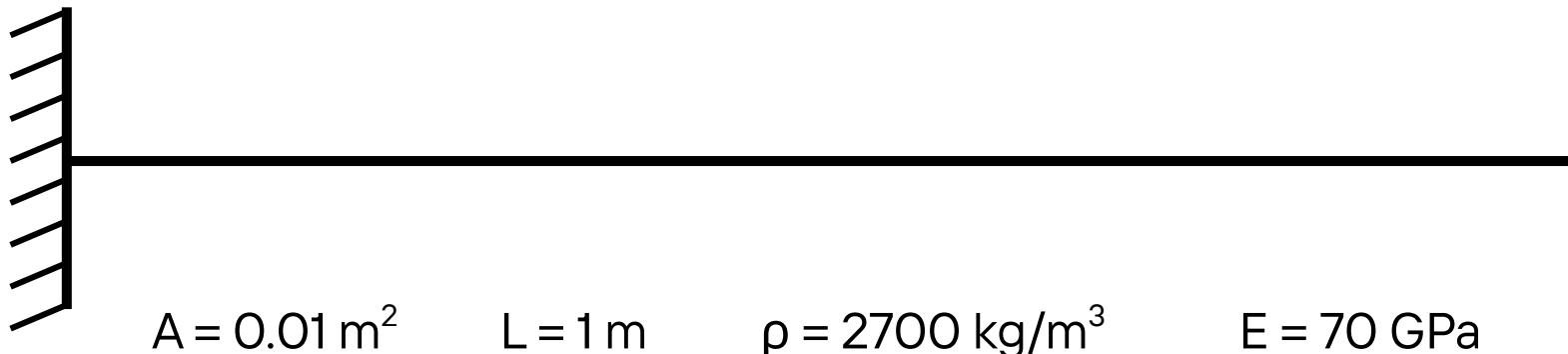
$$\begin{aligned} \Sigma F & \left\{ \begin{array}{l} \rho A(x)dx \frac{\partial^2 w(x,t)}{\partial t^2} = - (Q(x,t) + dQ) + f(x,t)dx + Q(x,t) \\ \Sigma M_o \end{array} \right. \\ & \left. \begin{array}{l} (M(x,t) + dM) - (Q(x,t) + dQ)dx + f(x,t)dx \frac{dx}{2} - M = 0 \end{array} \right. \end{aligned}$$

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

$$w(x, t) = y(x)q(t) \quad \Rightarrow \quad \begin{cases} \frac{d^2}{dx^2} \left[ EI(x) \frac{d^2y(x)}{dx^2} \right] - \omega^2 \rho A(x) y(x) = 0 \\ \frac{d^2q(t)}{dt^2} + \omega^2 q(t) = 0 \end{cases} \quad \xrightarrow{\hspace{10em}} \quad q(t) = a \cos \omega t + b \sin \omega t$$

# PARAMETROS DISTRIBUIDOS

Viga uniforme →  $EI = \text{cte}$   
 $\rho A = \text{cte}$



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

Condiciones de borde

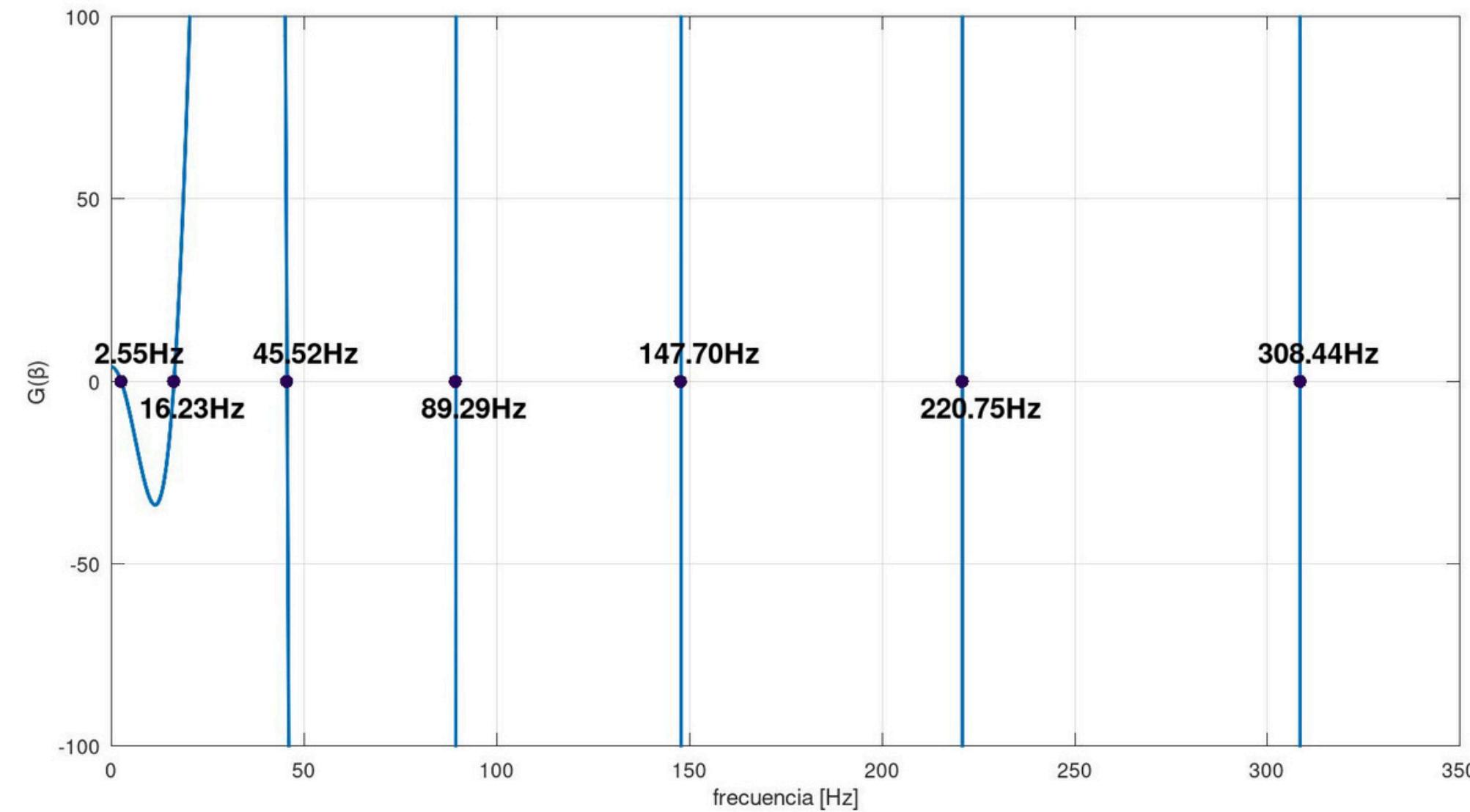
$$\begin{cases} y(0) = 0 \\ y'(0) = 0 \\ y''(L) = 0 \\ y'''(L) = 0 \end{cases} \quad \Rightarrow \quad$$

$$G(\beta) = (\cosh(\beta L) + \cos(\beta L))^2 - (\sinh(\beta L) - \sin(\beta L)) (\sinh(\beta L) + \sin(\beta L)) = 0$$

# PARAMETROS DISTRIBUIDOS

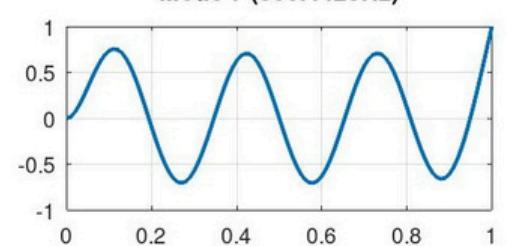
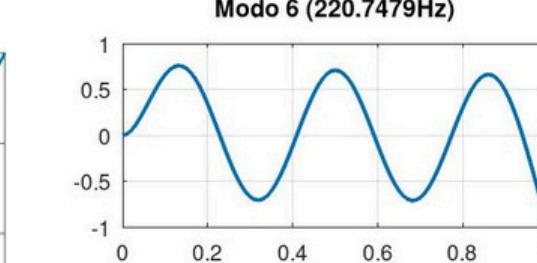
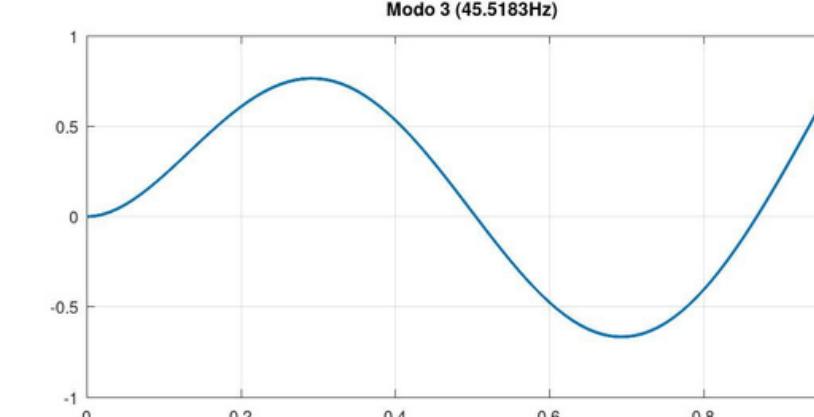
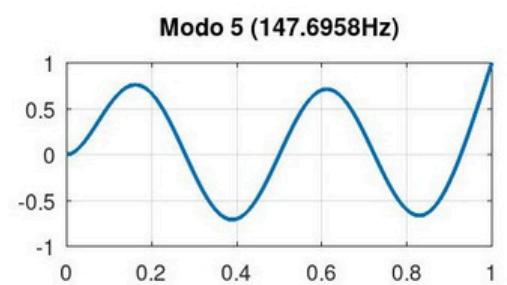
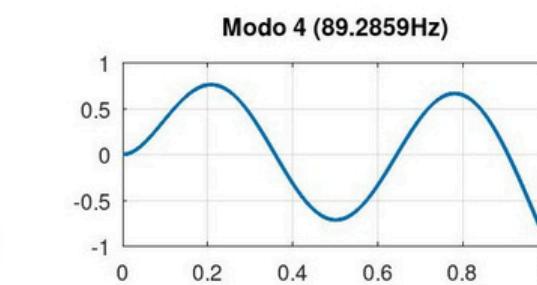
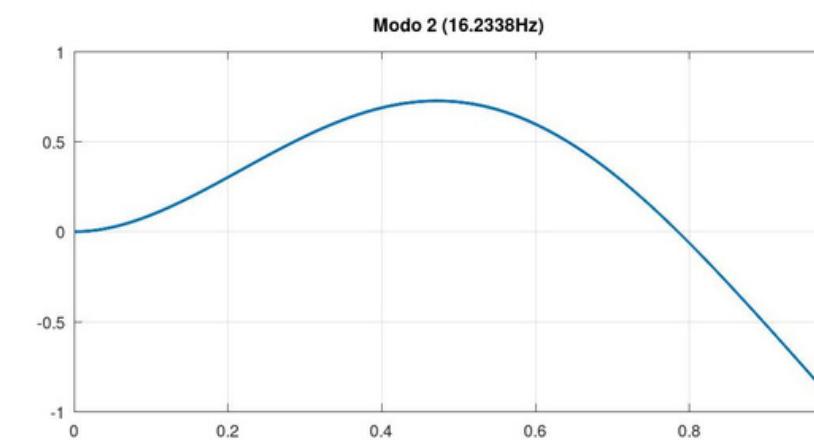
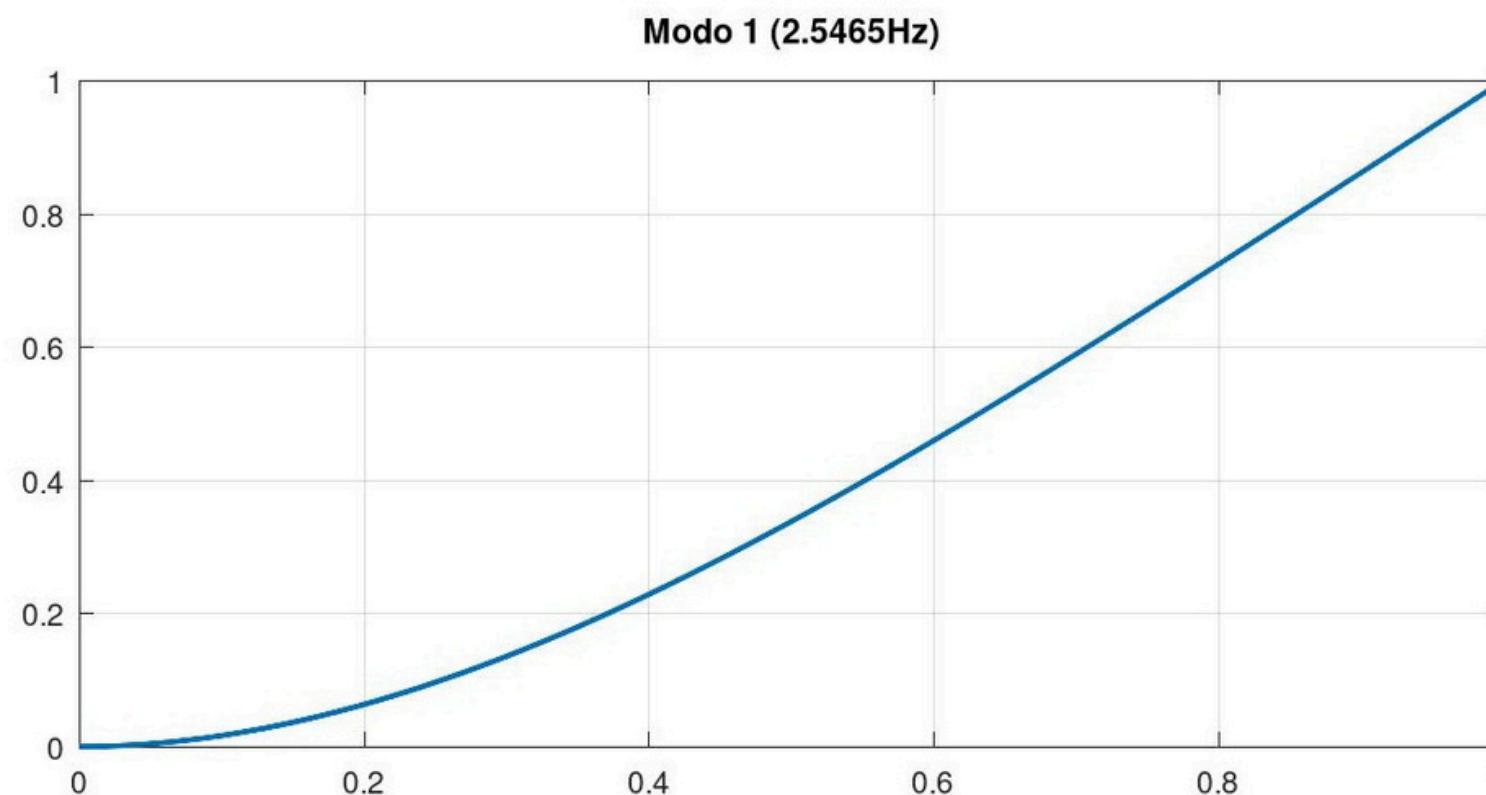
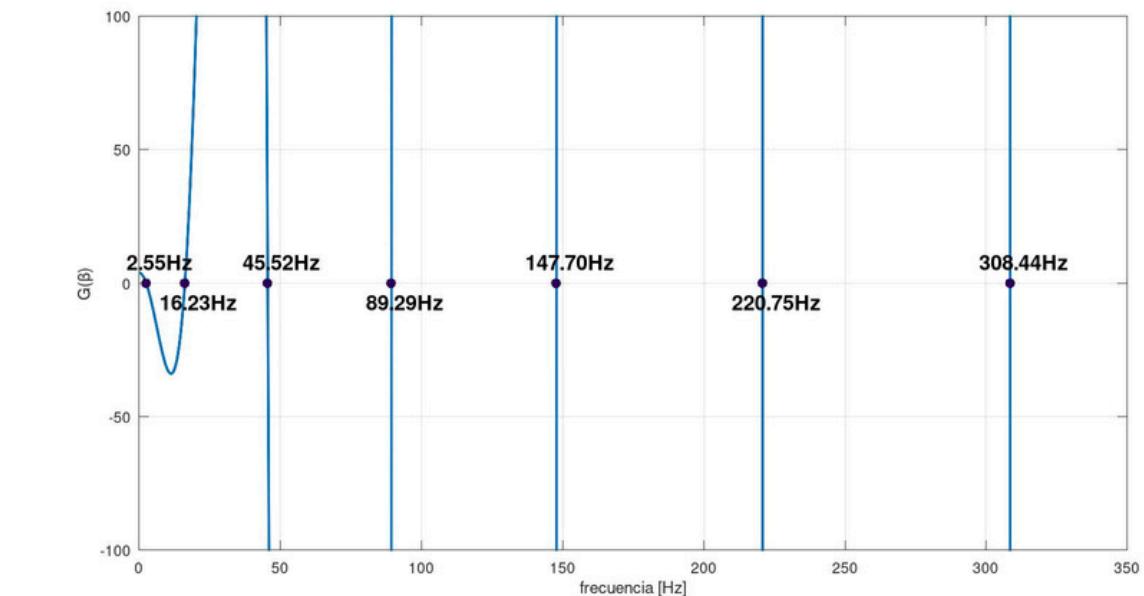
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Resolviendo numericamente



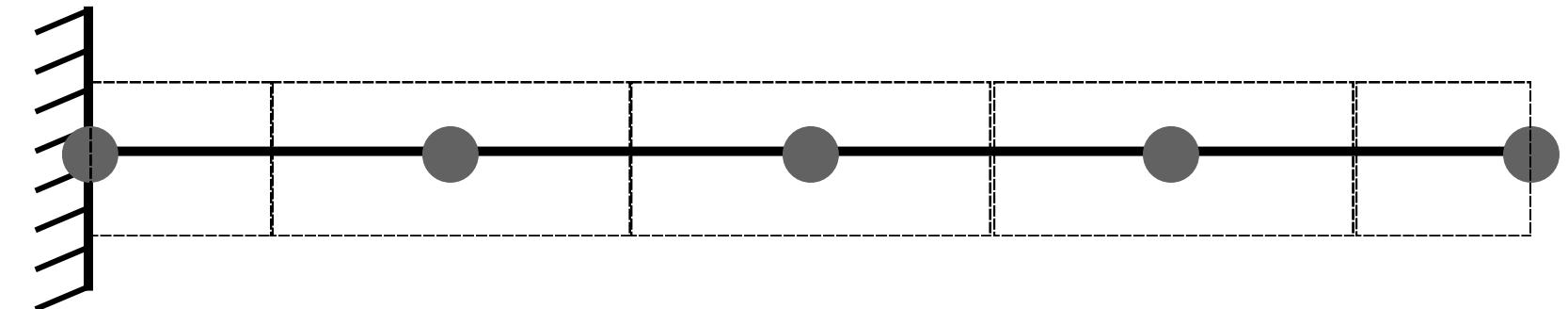
# PARAMETROS DISTRIBUIDOS

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# PARAMETROS CONCENTRADOS

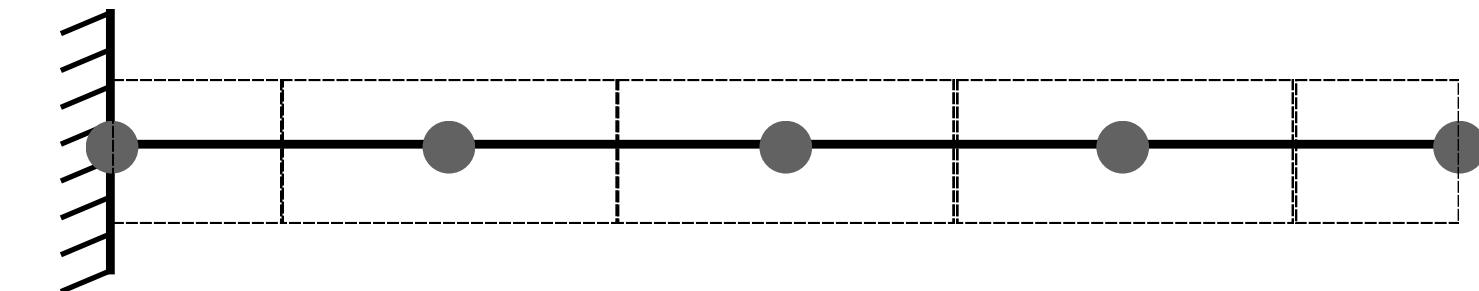
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$$\mathbf{M} \ddot{\mathbf{q}} + \mathbf{D} \dot{\mathbf{q}} + \mathbf{K} \mathbf{q} = \mathbf{F} \mathbf{u} \longrightarrow \ddot{\mathbf{q}} + [\mathbf{M}^{-1} \mathbf{D}] \dot{\mathbf{q}} + [\mathbf{M}^{-1} \mathbf{K}] \mathbf{q} = [\mathbf{M}^{-1}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

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

# PARAMETROS CONCENTRADOS



$\Lambda =$

$$\begin{bmatrix} 0.0019979 & 0.028947 & 0.016156 & 0.082385 & 0.050558 & -0.071548 & -0.057085 & \boxed{0.035277} \\ \cancel{0.0071052} & \cancel{0.53369} & \cancel{0.78439} & \cancel{-0.83293} & \cancel{0.041784} & \cancel{-0.28742} & \cancel{-0.33566} & \cancel{0.20521} \\ 0.014242 & -0.011127 & -0.077423 & -0.03621 & -0.029898 & -0.04039 & -0.11043 & 0.12412 \\ \cancel{-0.1392} & \cancel{0.81147} & \cancel{-0.23335} & \cancel{0.40469} & \cancel{-0.46709} & \cancel{0.5132} & \cancel{-0.014508} & \cancel{0.42954} \\ 0.025886 & -0.034163 & 0.062243 & 0.021099 & 0.0046728 & 0.06203 & -0.047224 & 0.24257 \\ \cancel{-0.76671} & \cancel{0.14583} & \cancel{-0.43833} & \cancel{-0.31024} & \cancel{0.6184} & \cancel{0.10856} & \cancel{0.51064} & \cancel{0.50568} \\ -0.083922 & 0.01986 & -0.034797 & -0.012394 & 0.012454 & -0.032388 & 0.11878 & 0.37207 \\ \cancel{-0.60695} & \cancel{-0.18141} & \cancel{0.35609} & \cancel{0.19368} & \cancel{-0.62772} & \cancel{-0.79409} & \cancel{0.77109} & \boxed{0.5249} \end{bmatrix}$$

$D =$

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

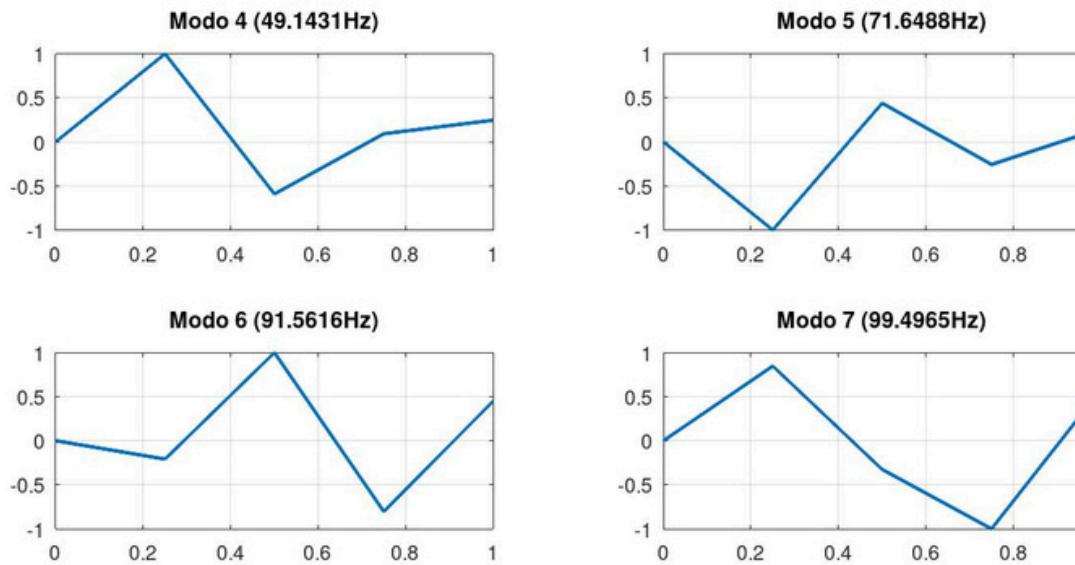
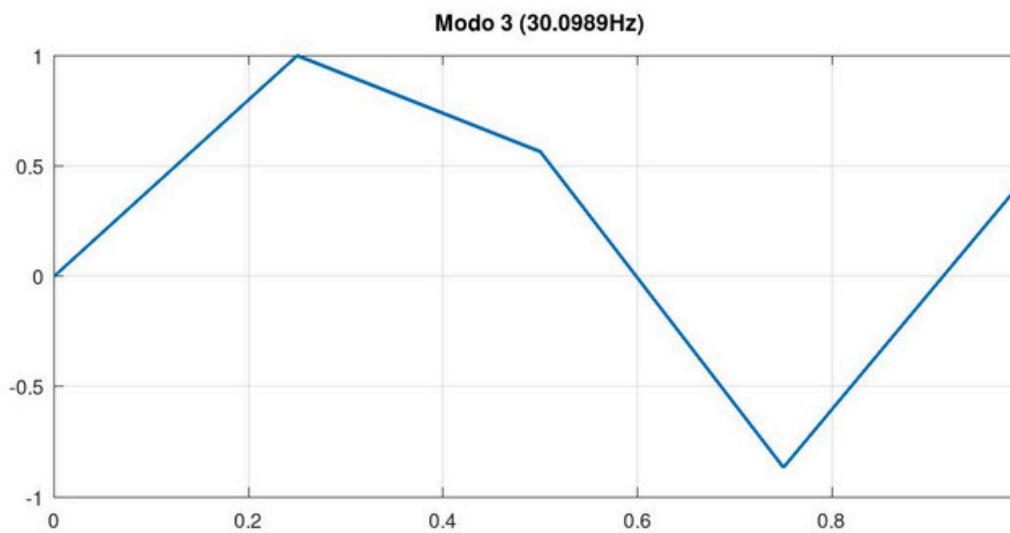
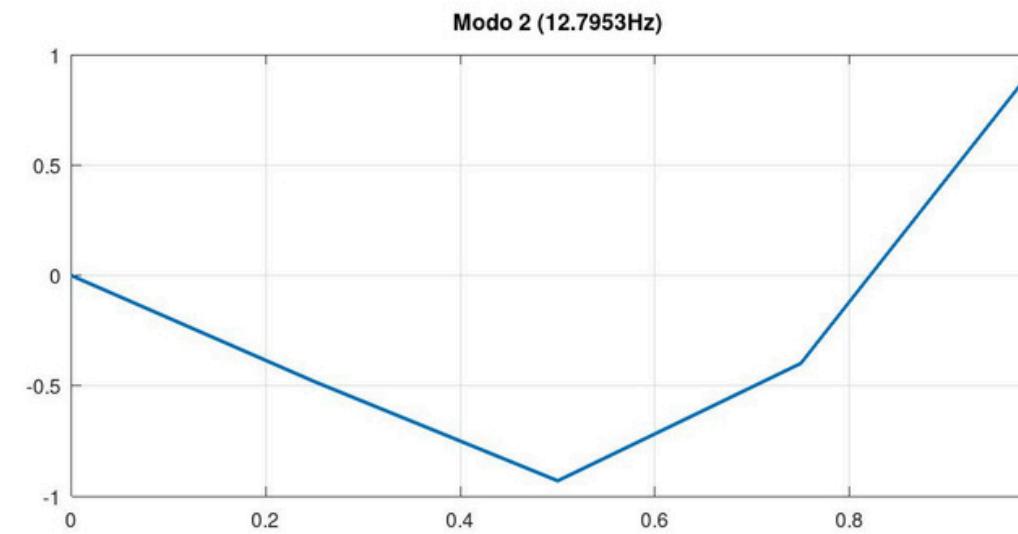
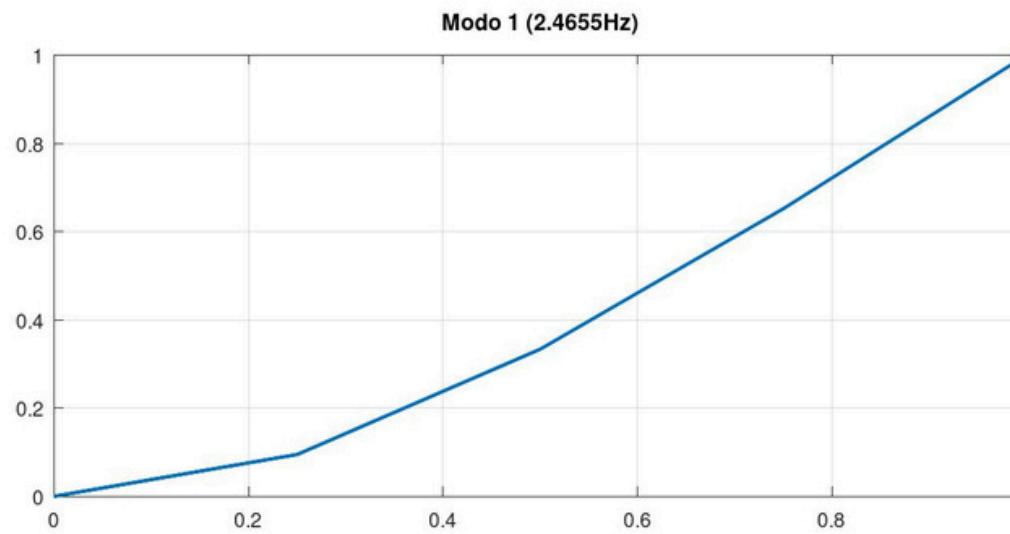
$v_1$

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

# PARAMETROS CONCENTRADOS

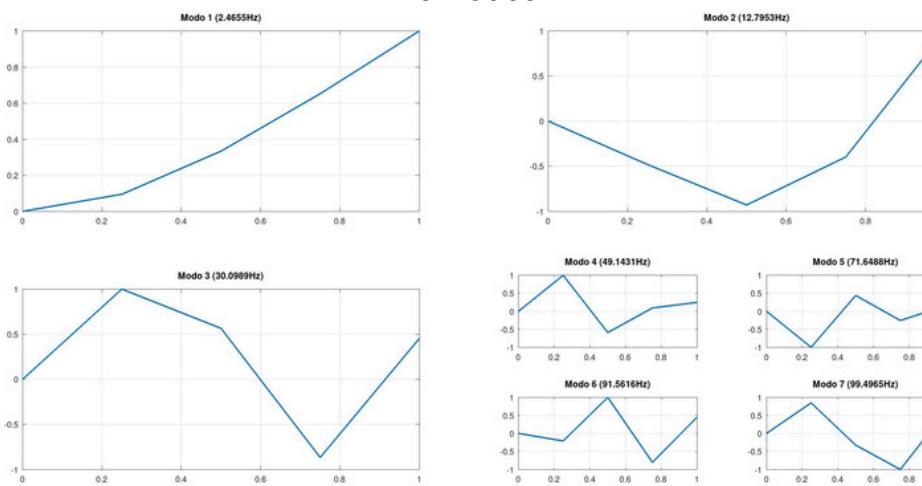
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5 Nodos

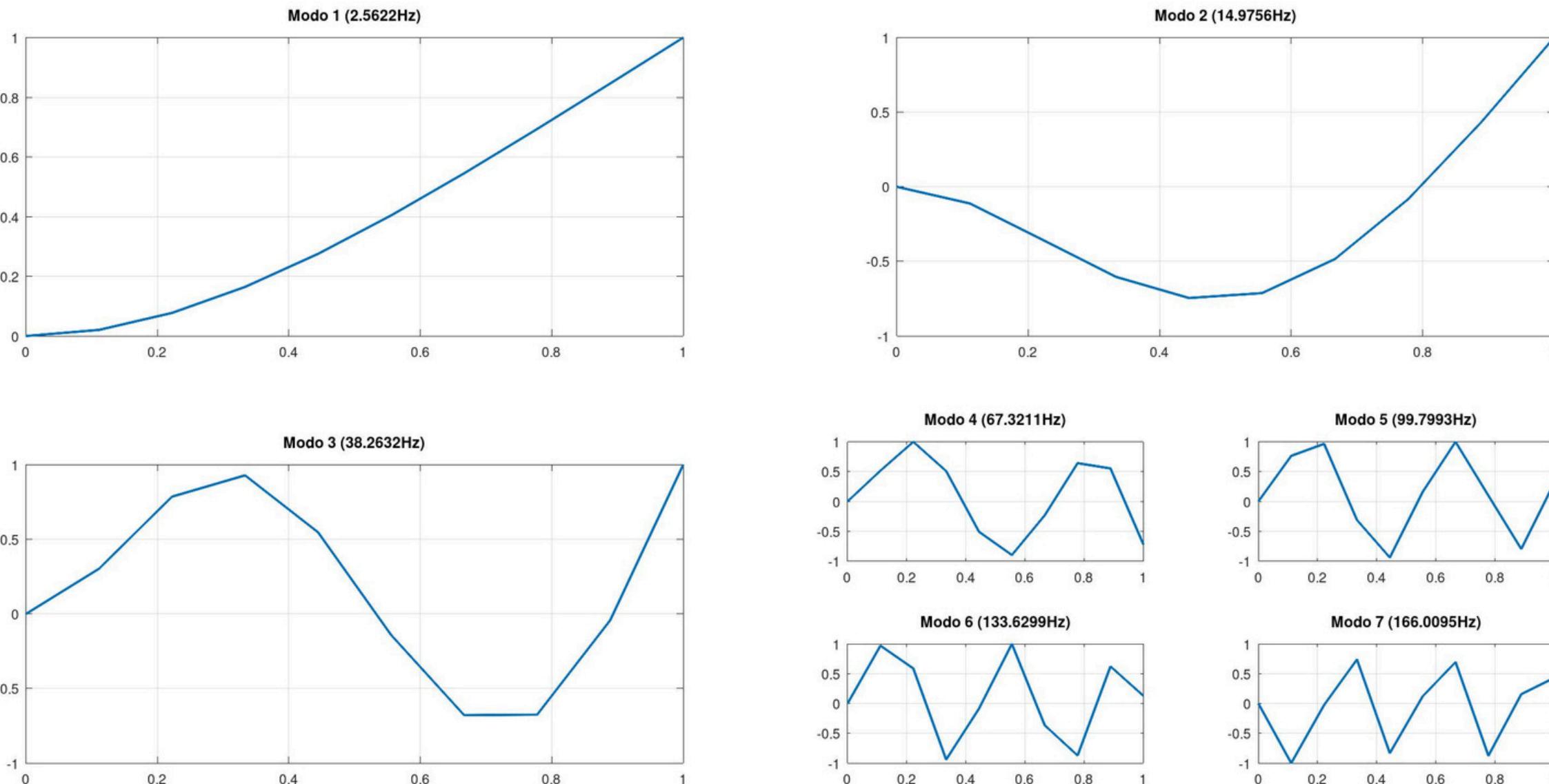


# PARAMETROS CONCENTRADOS

5 Nodos

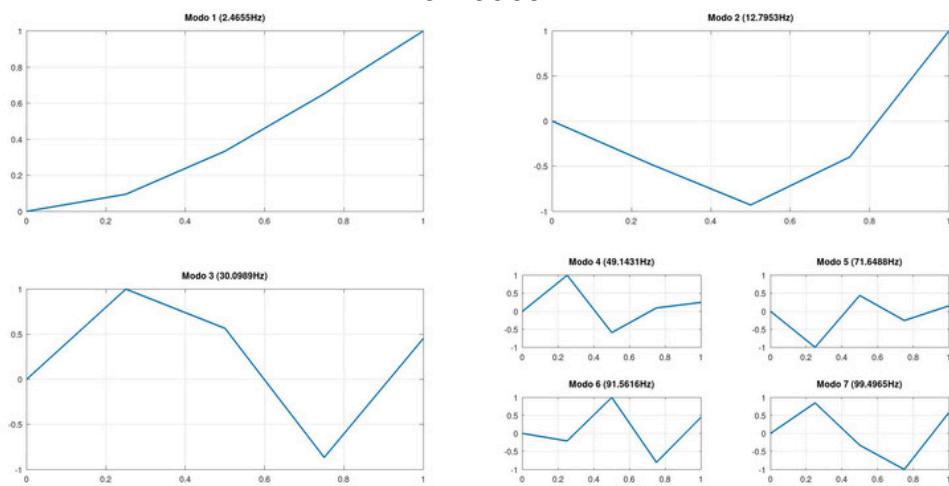


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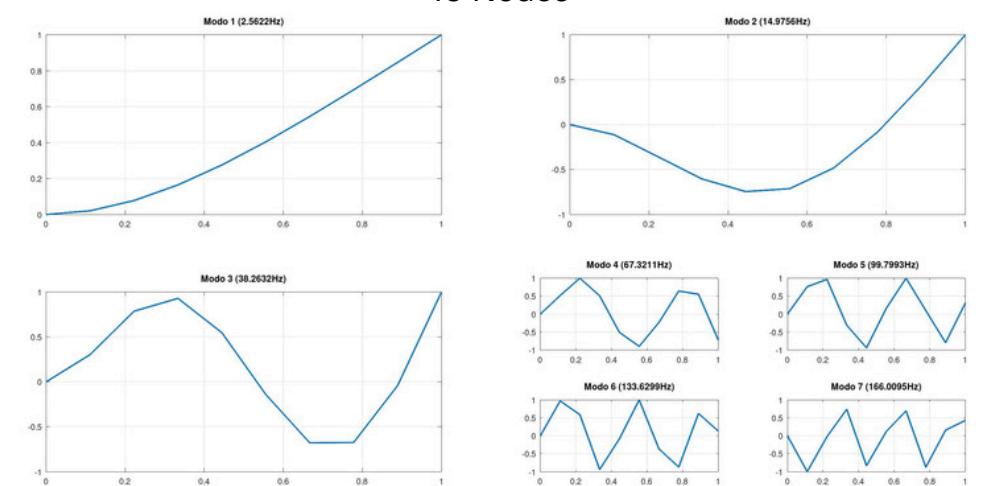


# PARAMETROS CONCENTRADOS

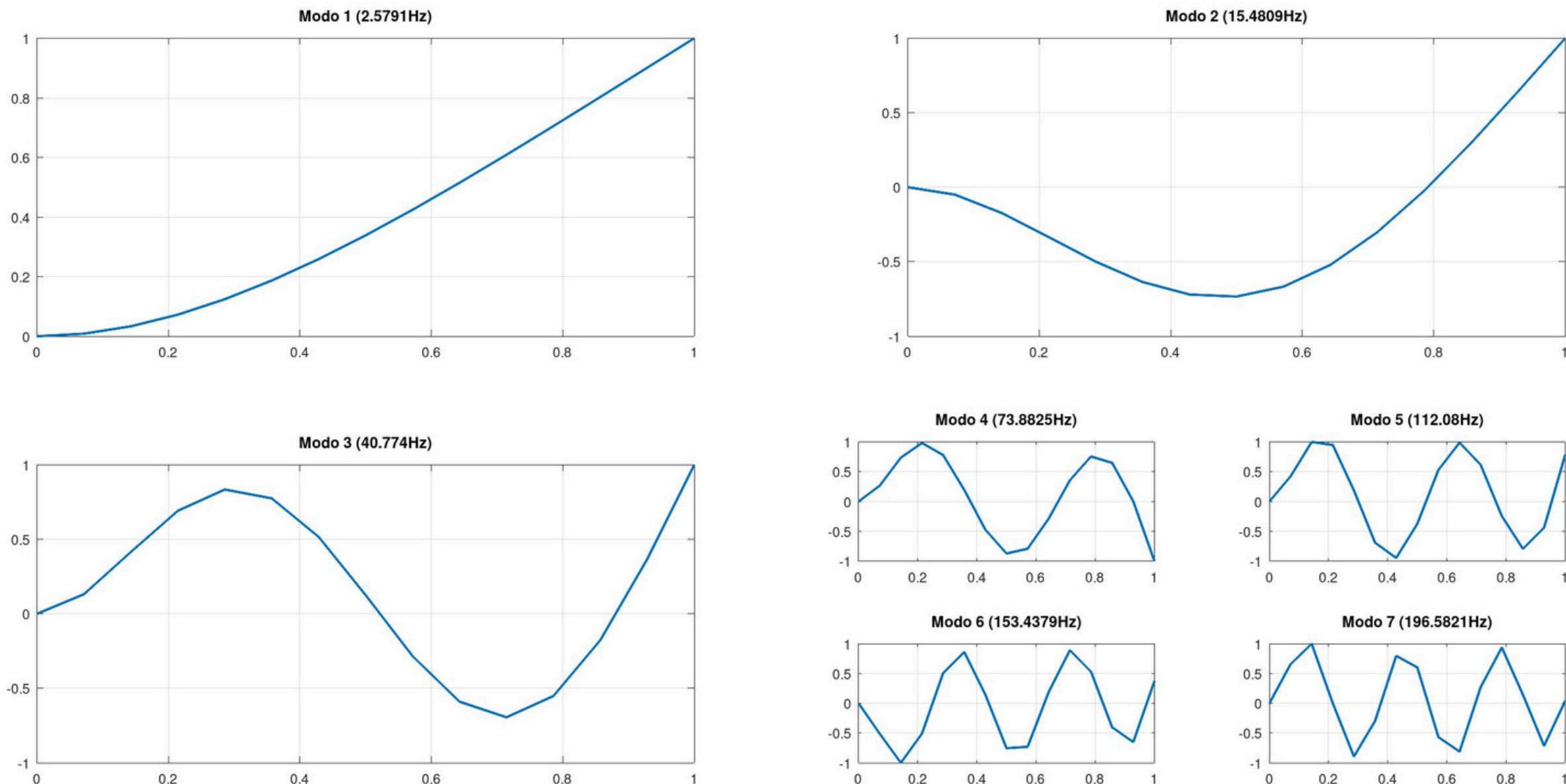
5 Nodos



10 Nodos

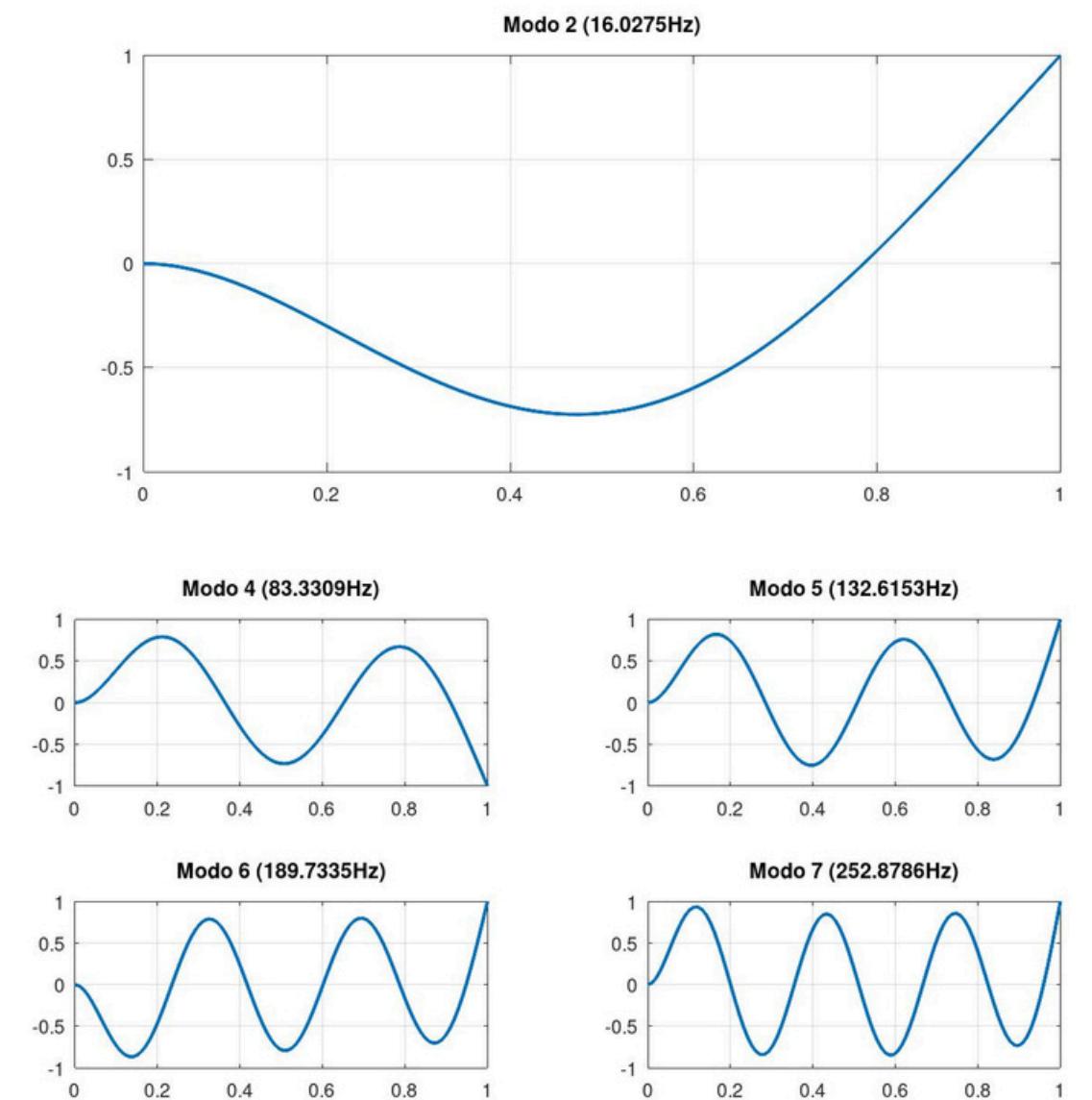
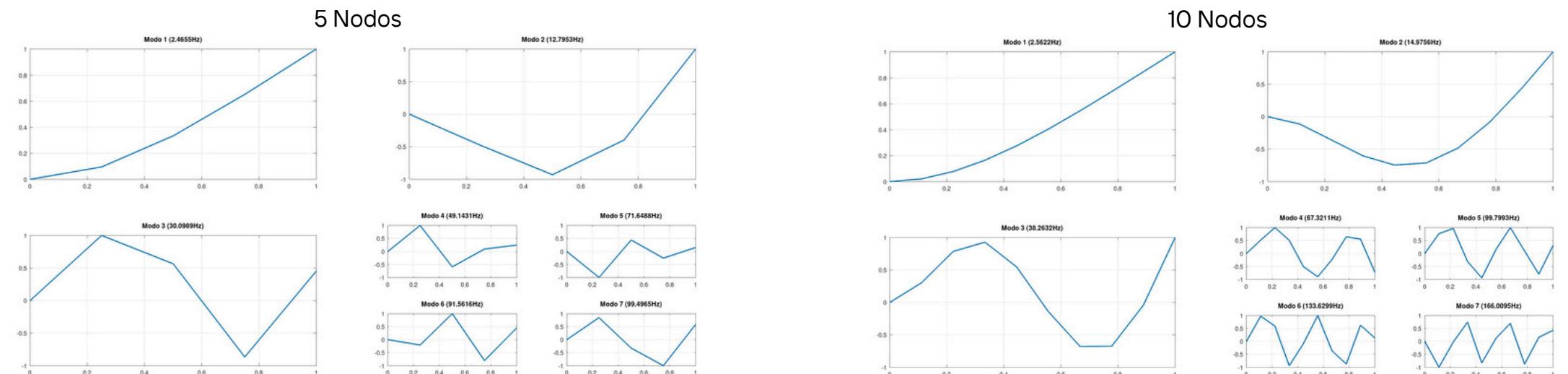
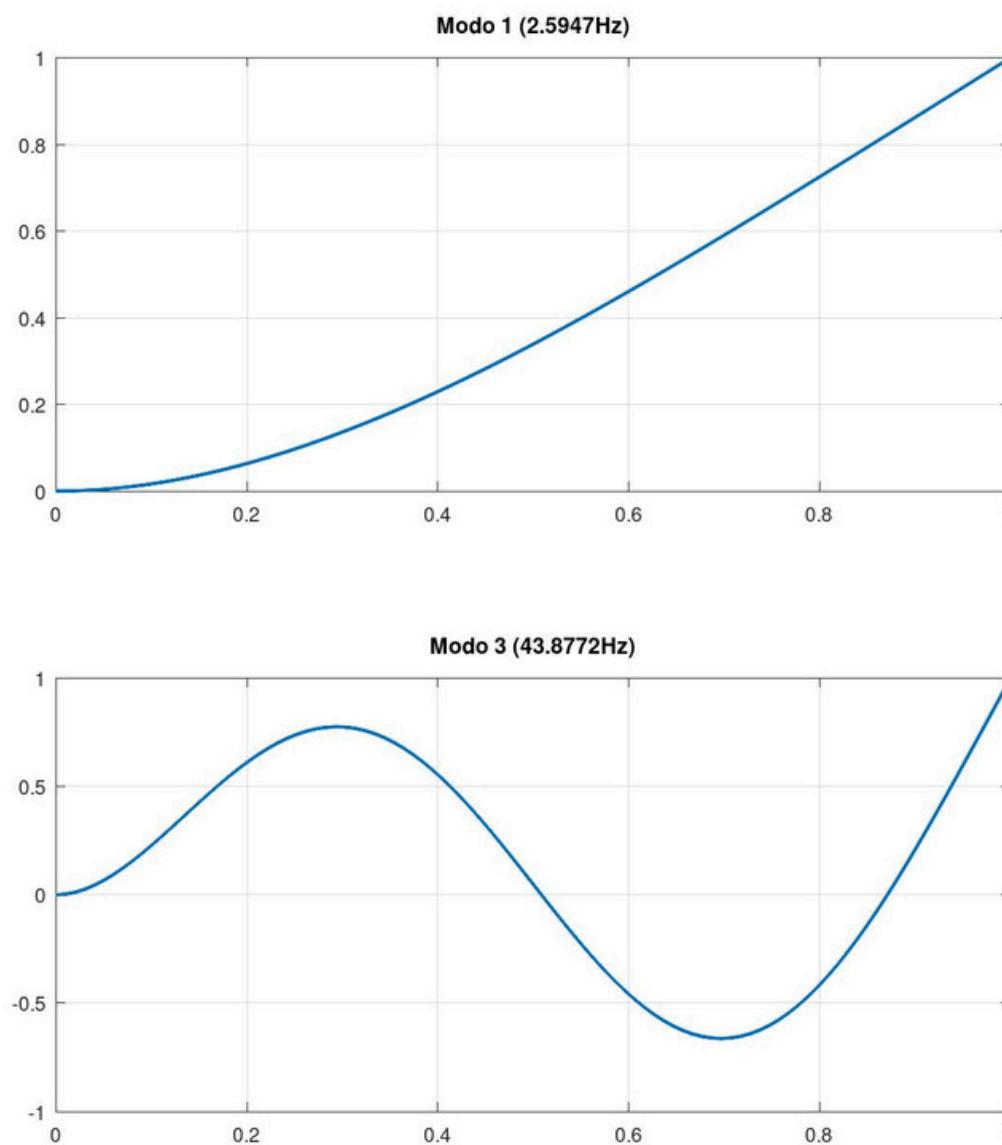


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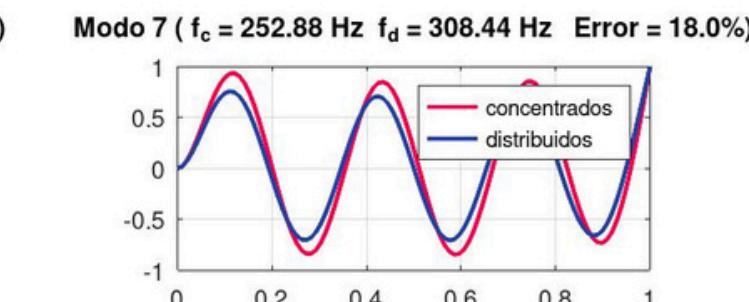
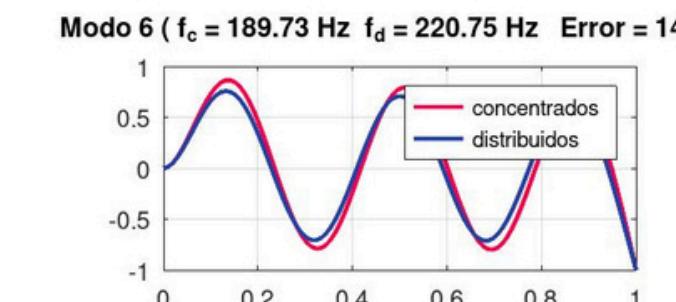
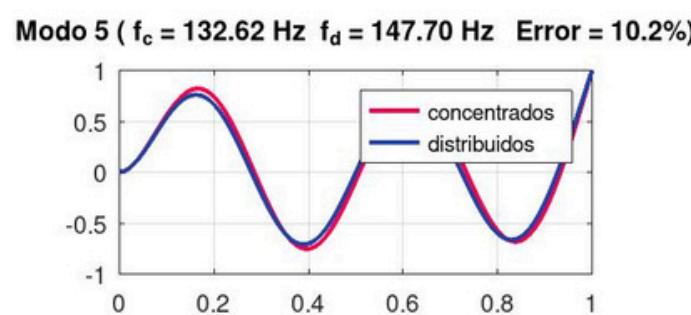
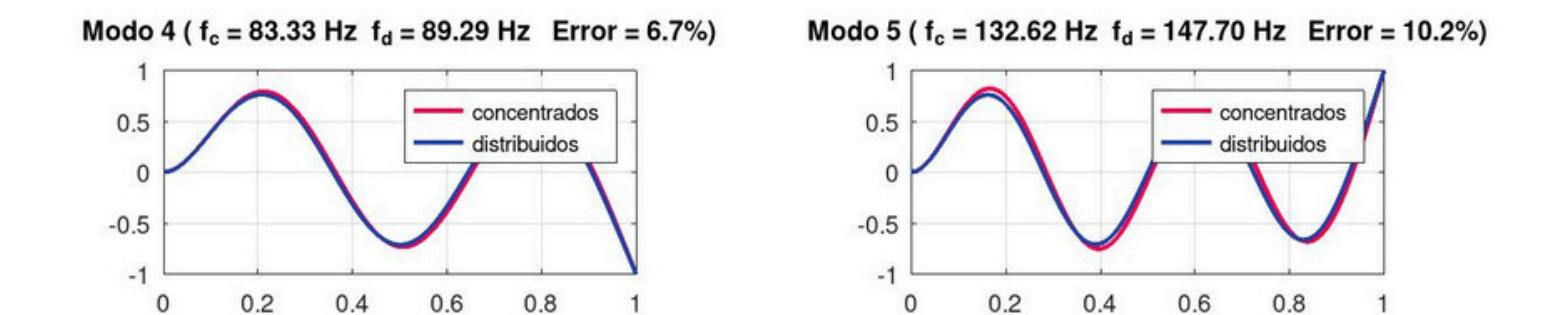
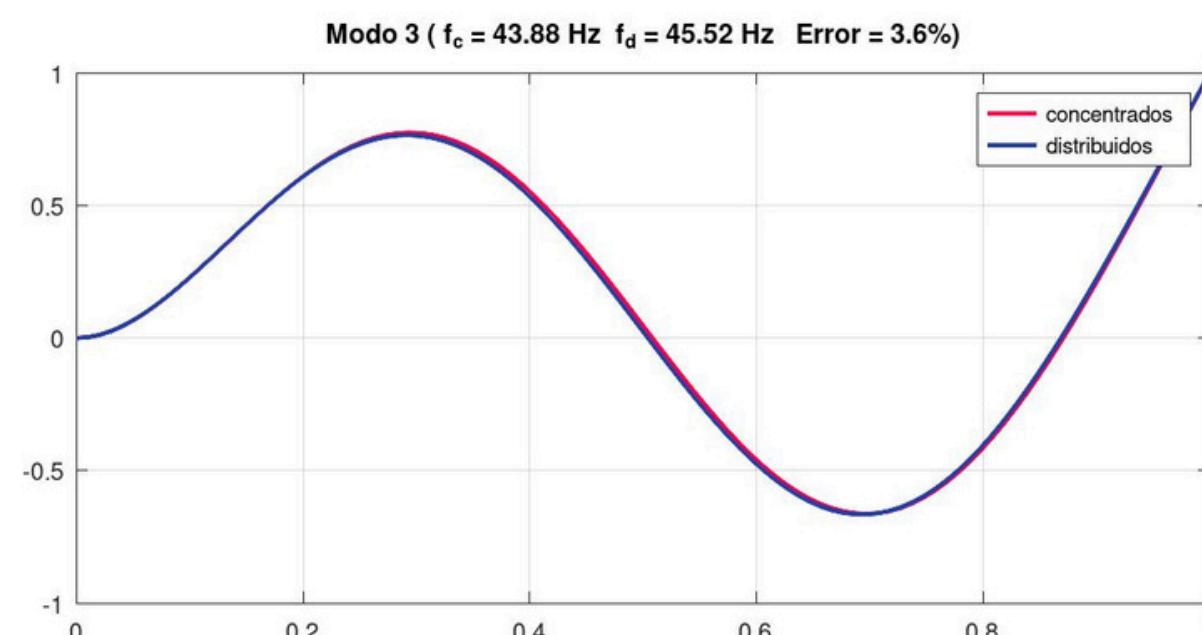
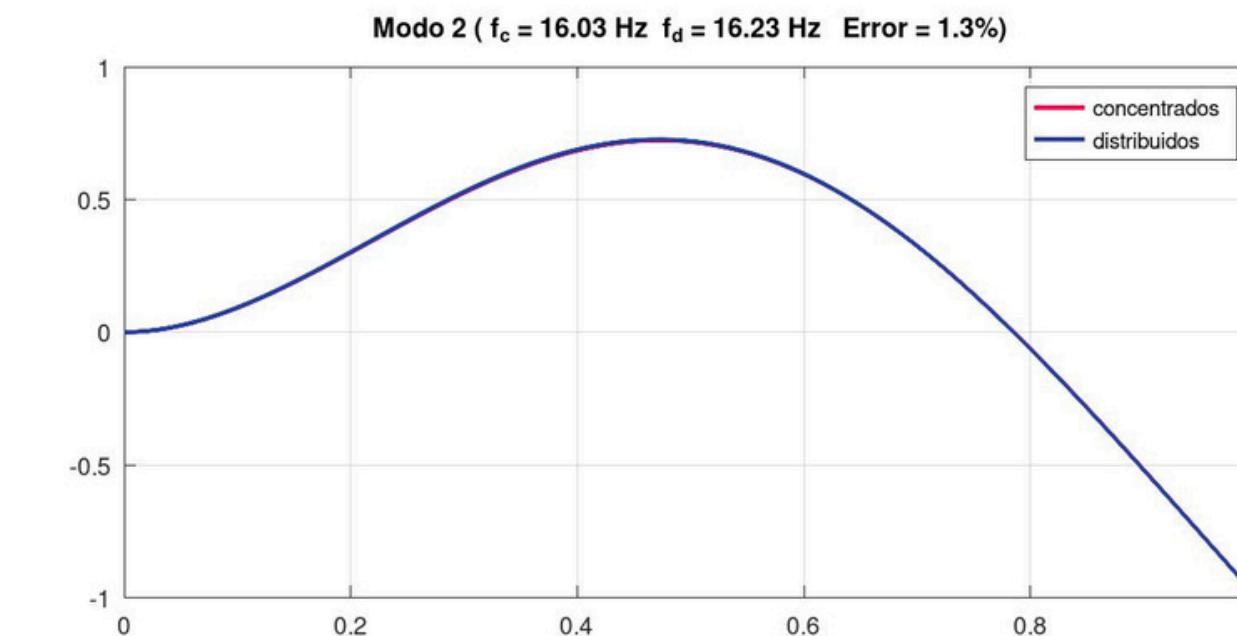
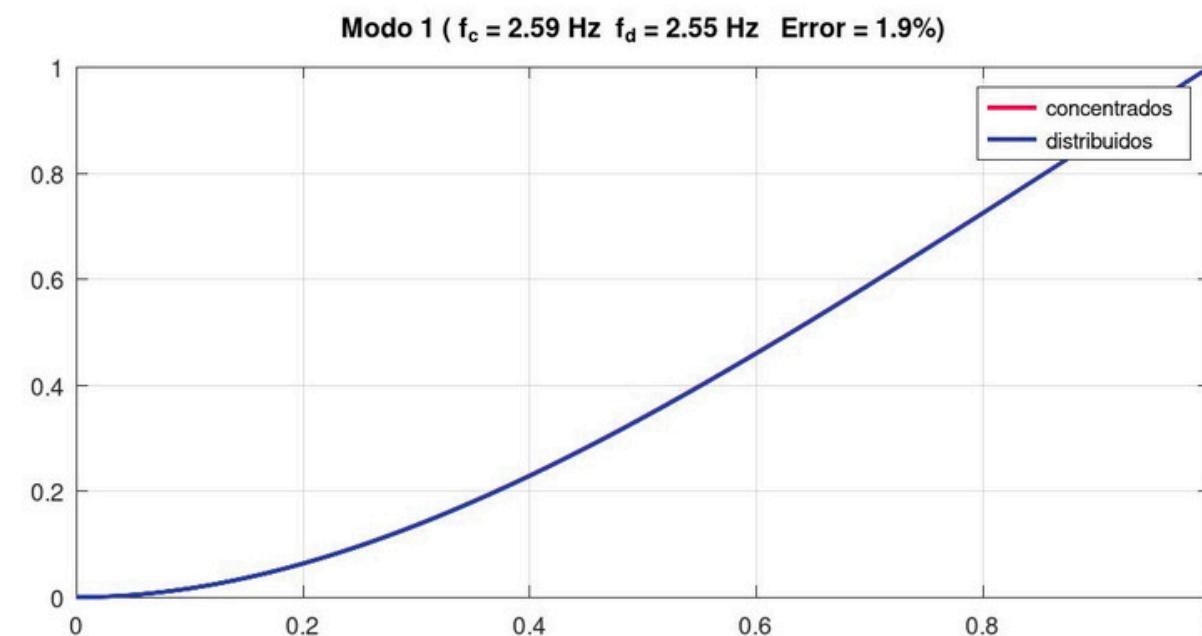


# PARAMETROS CONCENTRADOS

100 Nodos



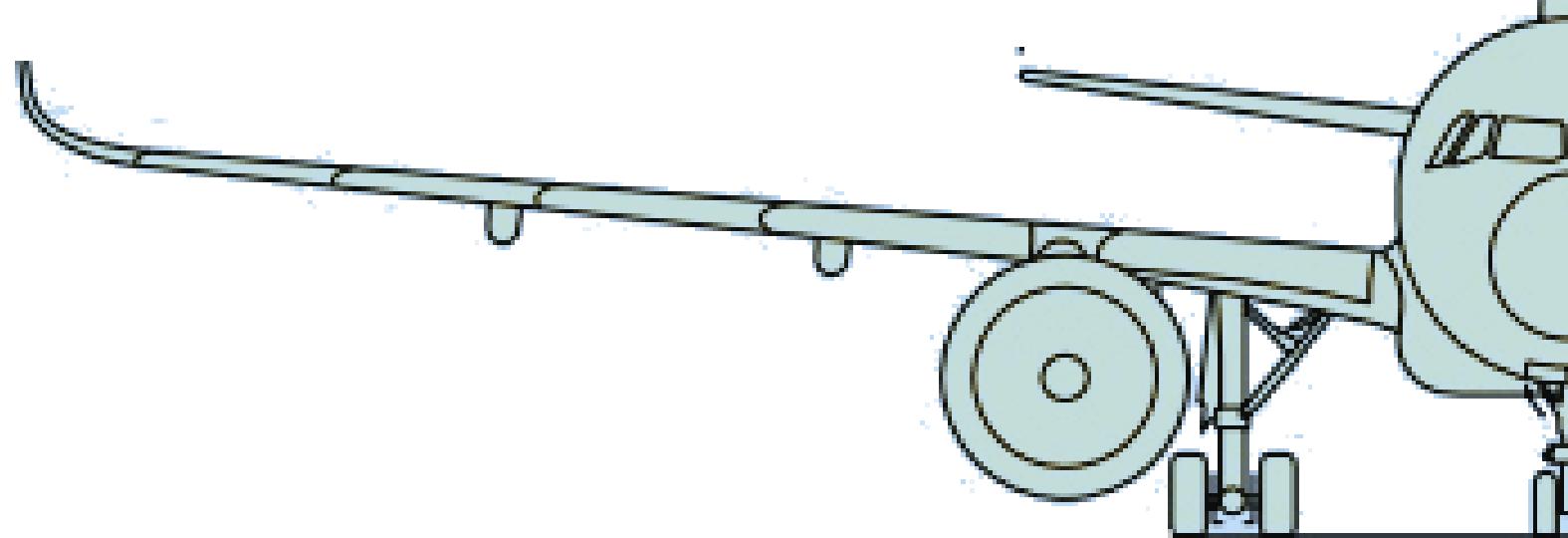
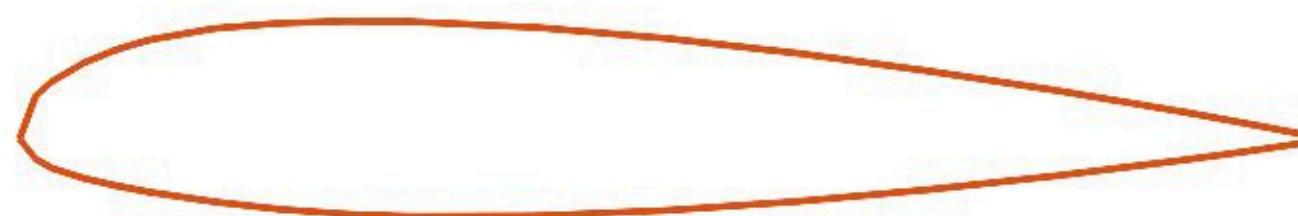
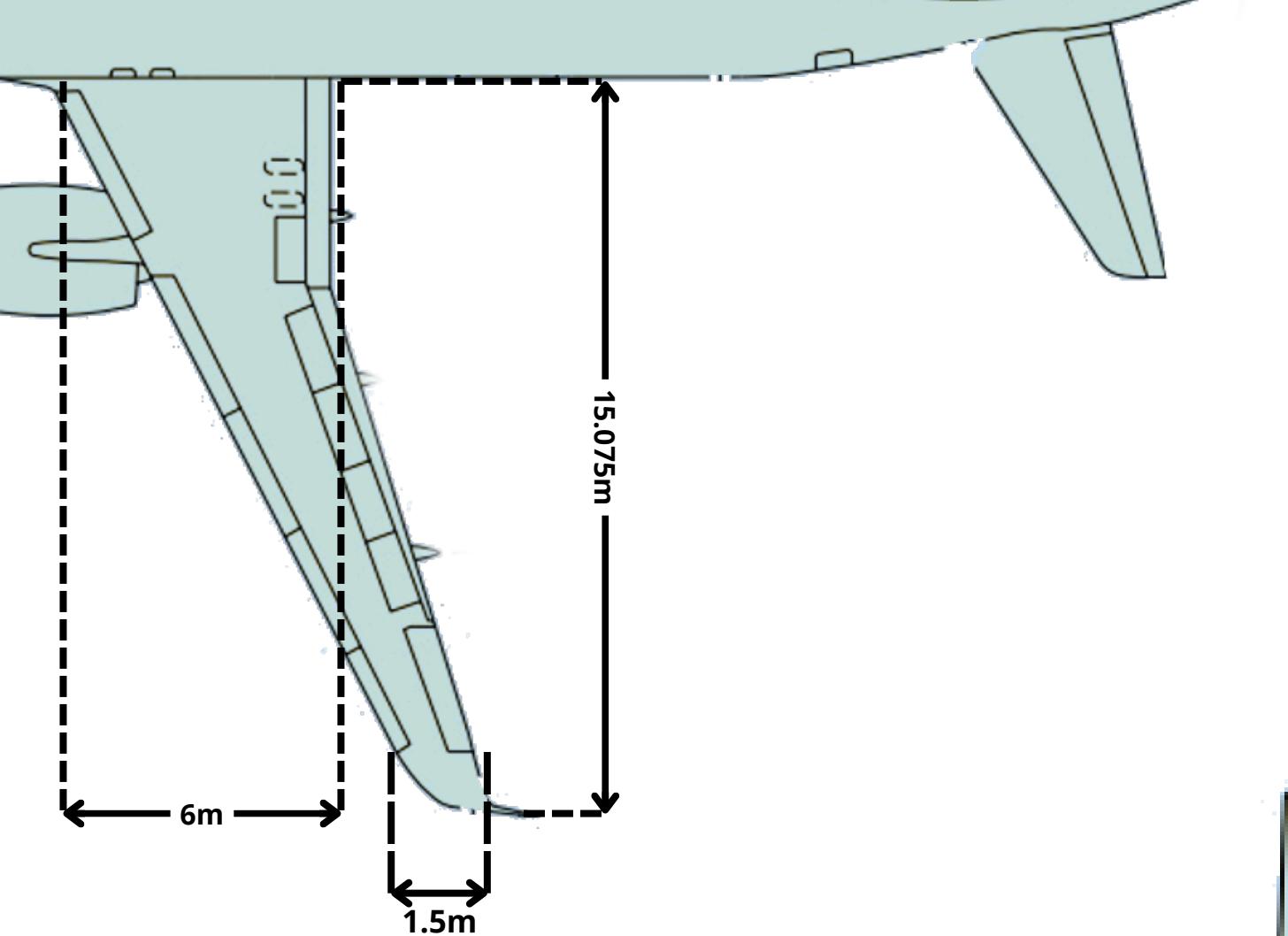
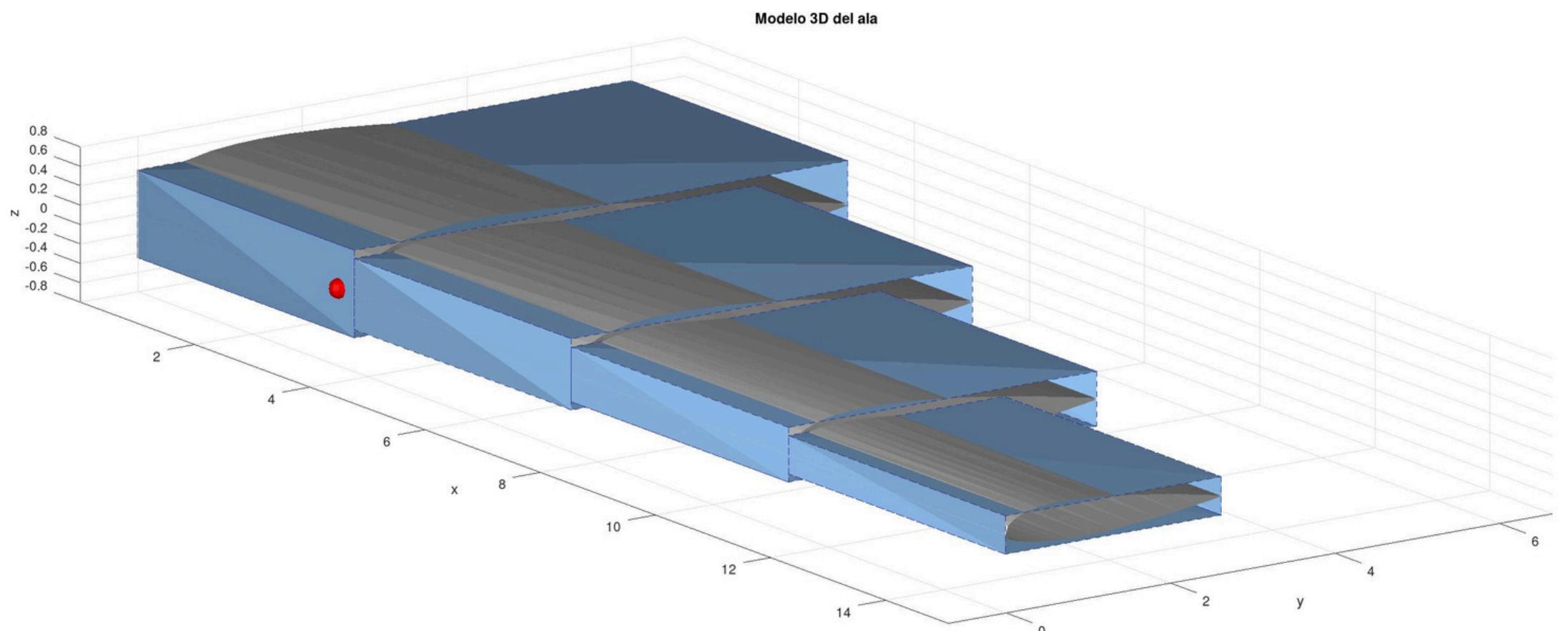
# COMPARACION



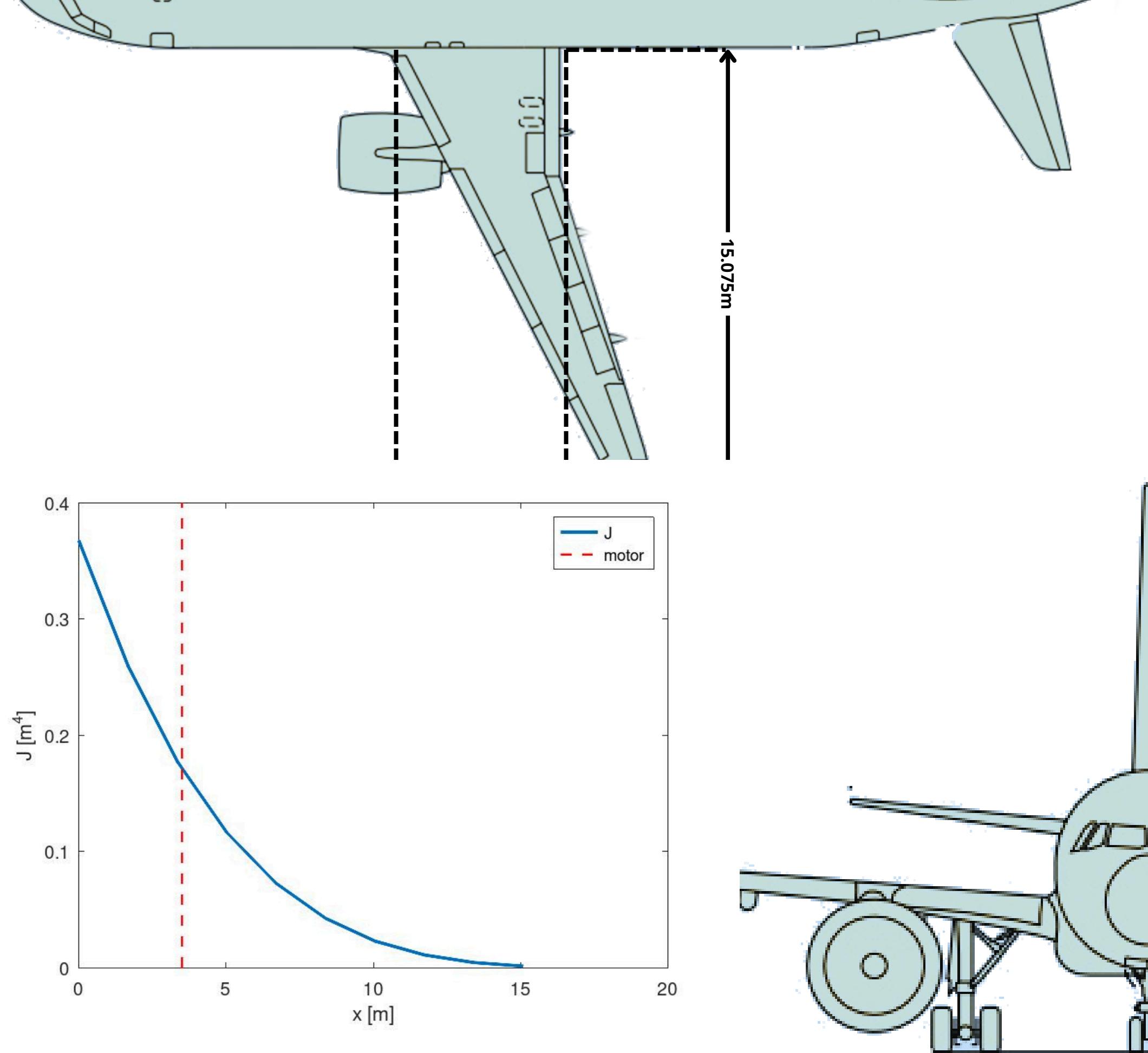
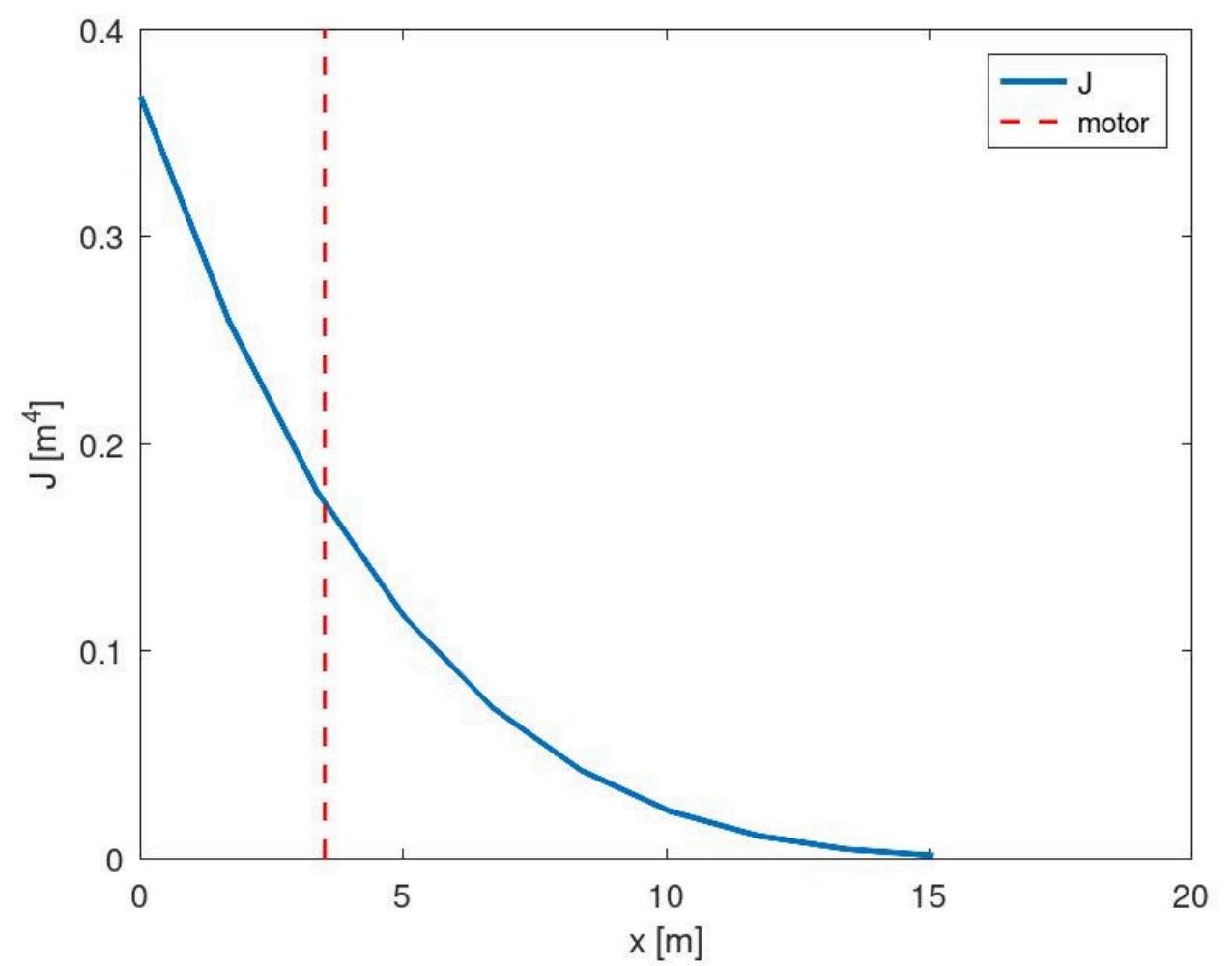
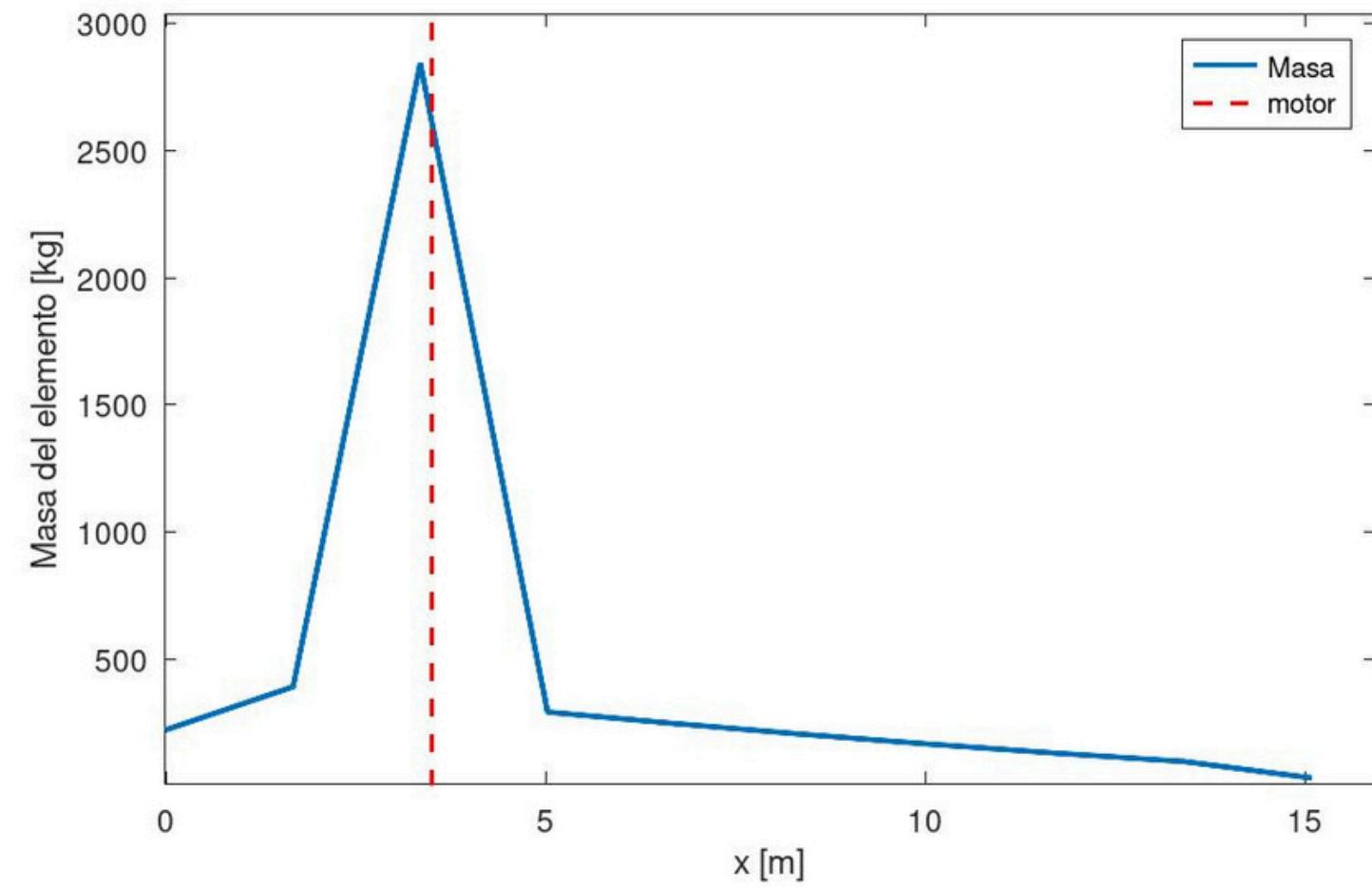
# **MODELO DE ALA DE UN A320**

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# MODELADO

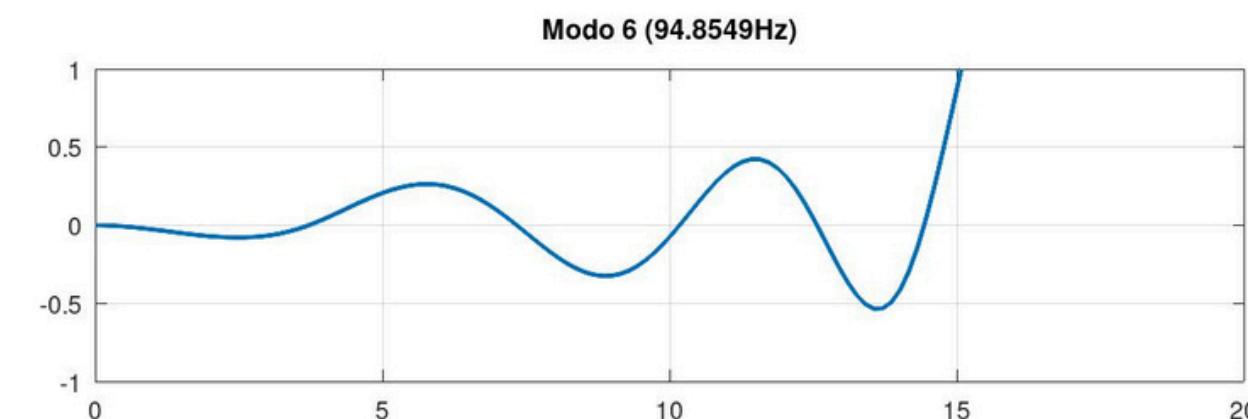
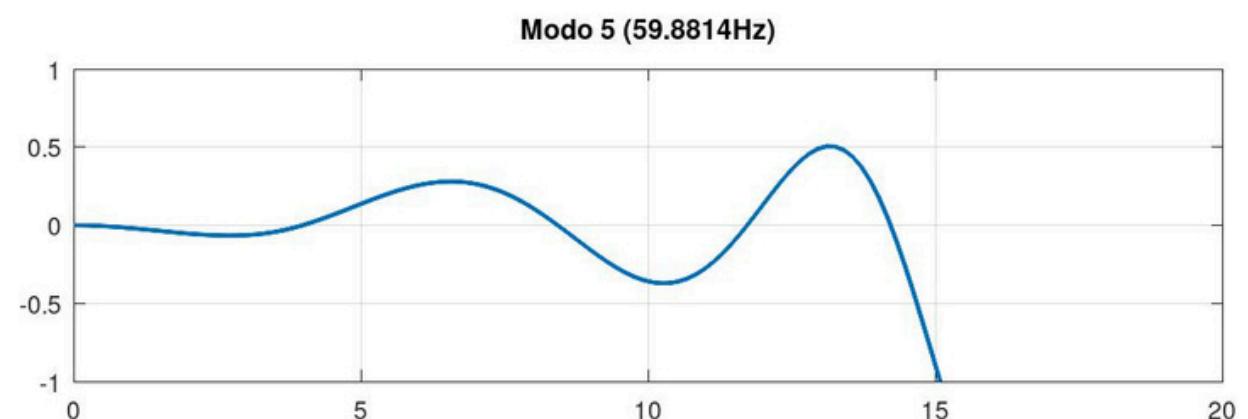
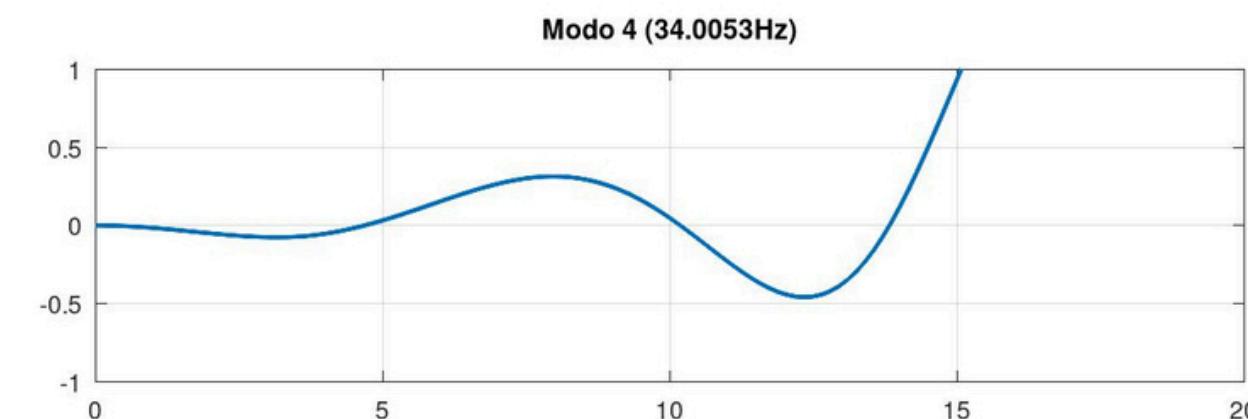
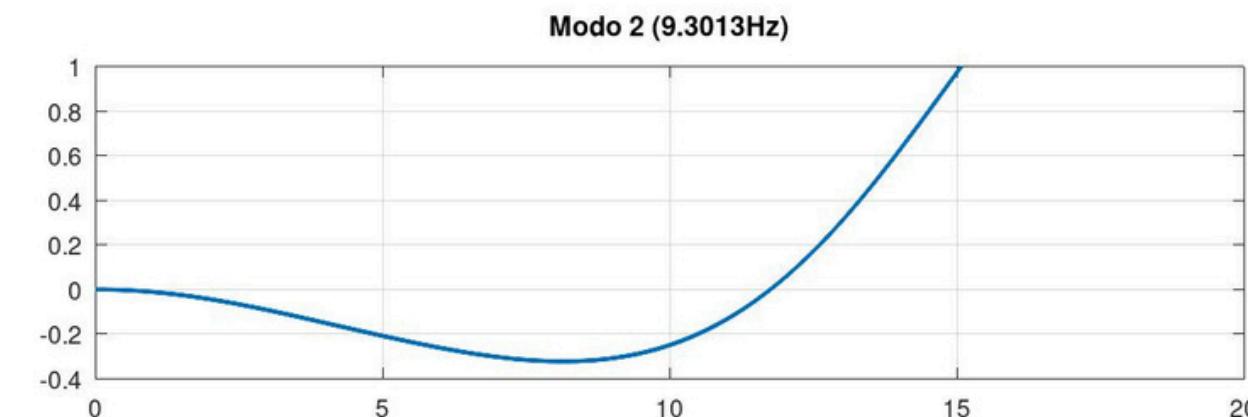
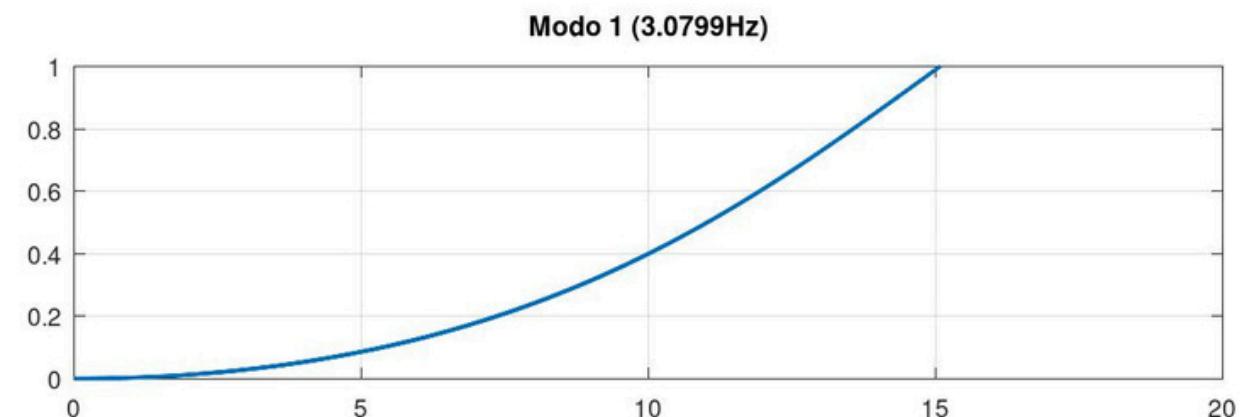


# MODELADO



# RESULTADOS

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**GRACIAS POR  
ESCUCHAR**

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