exercicio_2

May 9, 2022

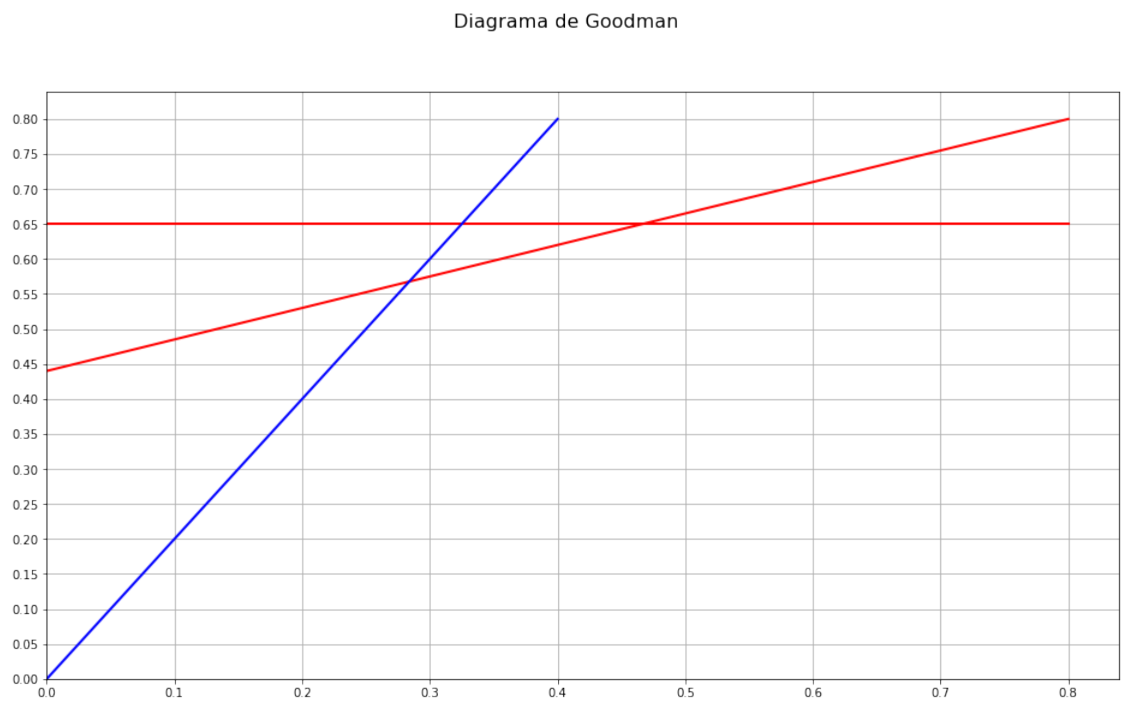
[ ]:
```python
import numpy as np
import matplotlib.pyplot as plt
from scipy.interpolate import interp1d
import pandas as pd
```

[ ]:
```python
def C_converge(C_t,d,tau,F_max):

    k = 0

    while k < 100:

        Ks = (4*C_t - 1)/(4*C_t - 4) + 0.675/C_t

        C_p = tau*np.pi*d**2/(8*F_max*Ks)

        error = ((C_p-C_t)**2)**0.5

        C_t = (C_p+C_t)/2

        if error <= C_t*0.01:
            return C_t
```

[ ]:
```python
# constantes

Su = 1250e6
Su_lim = 0.80
Su_vida_inf = 0.44
Sy_lim = 0.65
F_min = 250
F_max = 500
Fs = 1.1 * F_max
delta_p = 25e-3
G = 79e9
E = 207e9
rho = 7700
```

[ ]:

```python
# plotagem diagrama de goodman

fig = plt.figure(figsize=[16, 9])
fig.suptitle('Diagrama de Goodman modificado', fontsize=16)

linha_sobrecarga_1 = np.array(
    ([0,Su_vida_inf],
    [Su_lim,Su_lim])
)

linha_sobrecarga_2 = np.array(
    ([0,Sy_lim],
    [Su_lim,Sy_lim])
)

linha_carga = np.array(
    ([0,0],
    [Su_lim*(F_min/F_max),Su_lim])
)



# Plotando 2D

ax = fig.add_subplot(1, 1, 1)

ax.plot(linha_sobrecarga_1[:,0], linha_sobrecarga_1[:,1], 'r', linewidth=2)
ax.plot(linha_sobrecarga_2[:,0], linha_sobrecarga_2[:,1], 'r', linewidth=2)
ax.plot(linha_carga[:,0], linha_carga[:,1], 'b', linewidth=2)

ax.set_xlim(0)
ax.set_ylim(0)
ax.locator_params(axis='y', nbins=20)
ax.grid()

plt.show()
```



[ ]:
```python
# encontrando tensão limite

tensao_max_teorico = 0.52 * Su

f_seguranca = 0.1

f_mola_solida = 0.1

tensao_max = tensao_max_teorico/(1+f_seguranca)/(1+f_mola_solida)
print('{:.2e} MPa'.format(tensao_max/1e6))
```

```
5.37e+02 MPa
```

[ ]:
```python
# estabelecendo um diãmetro alvo

C_t = 10

Kw = (4*C_t - 1)/(4*C_t - 4) + 0.615/C_t

d_alvo = (8*F_max*C_t*Kw/(np.pi*tensao_max))**0.5

print('{:.2e} mm'.format(d_alvo*1e3))
```

```
5.21e+00 mm
```

[ ]:
```python
k = (F_max-F_min)/delta_p
k
```

[ ]: 10000.0

[ ]:
```python
# iterando diâmetros para achar a melhor solução

d_mm_list = np.linspace(4,18,num=15,dtype=int)

C_list = []
D_list = []
Nt_list = []
Lf_D_list = []
delta_Lf_list = []
V_list = []
P_list = []
fn_list = []
d_list = []

for i,d_mm in enumerate(d_mm_list):

    d = d_mm*1e-3

    C = C_converge(C_t,d,tensao_max,F_max)

    D = C * d

    N = d * G/(8 * C**3 * k)

    N_t = N + 2

    Ls = N_t * d

    delta = Fs/k

    L_f = Ls + delta

    Lf_D = L_f/D

    delta_Lf = delta/L_f

    V = (np.pi * d **2 / 4) * 2*np.pi *D/2

    P = V * rho

    fn = 353e3*d/(N*D**2) * 60
```

```
    C_list.append(C)
    D_list.append(D)
    Nt_list.append(N_t)
    Lf_D_list.append(Lf_D)
    delta_Lf_list.append(delta_Lf)
    V_list.append(V)
    P_list.append(P)
    fn_list.append(fn)
    d_list.append(d)

df = pd.DataFrame(np.vstack((
        d_list,
        C_list,
        D_list,
        Nt_list,
        Lf_D_list,
        delta_Lf_list,
        V_list,
        P_list,
        fn_list
    )).T,columns=[
            'd',
            'C',
            'D',
            'Nt',
            'Lf/D',
            'delta/Lf',
            'V',
            'P',
            'fn'
        ])

df
```

[ ]:

	d	C	D	Nt	Lf/D	delta/Lf	V	\
0	0.004	5.183055	0.020732	30.368715	8.512106	0.311659	8.184752e-07	
1	0.005	9.089688	0.045448	8.574461	2.153480	0.561957	2.803488e-06	
2	0.006	13.643828	0.081863	4.332811	0.989420	0.679039	7.271596e-06	
3	0.007	19.137260	0.133961	2.986270	0.566613	0.724601	1.619622e-05	
4	0.008	25.441376	0.203531	2.479739	0.367698	0.734922	3.214033e-05	
5	0.009	32.584411	0.293260	2.256892	0.256810	0.730295	5.861073e-05	
6	0.010	40.566833	0.405668	2.147919	0.188526	0.719150	1.000946e-04	
7	0.011	49.388901	0.543278	2.090166	0.143558	0.705202	1.621986e-04	
8	0.012	59.050764	0.708609	2.057550	0.112461	0.690169	2.517729e-04	
9	0.013	69.552513	0.904183	2.038154	0.090132	0.674880	3.770358e-04	
10	0.014	80.894207	1.132519	2.026116	0.073611	0.659744	5.476982e-04	
11	0.015	93.075886	1.396138	2.018370	0.061080	0.644968	7.750875e-04	

```
12  0.016  106.097575  1.697561   2.013229  0.051375  0.630650  1.072272e-03
13  0.017  119.959294  2.039308   2.009725  0.043723  0.616832  1.454188e-03
14  0.018  134.661056  2.423899   2.007279  0.037597  0.603527  1.937757e-03

            P            fn
0    0.006302  6.947918e+06
1    0.021587  7.798262e+06
2    0.055991  8.128728e+06
3    0.124711  8.376692e+06
4    0.247481  8.526081e+06
5    0.451303  8.628071e+06
6    0.770729  8.700815e+06
7    1.248929  8.754530e+06
8    1.938651  8.795325e+06
9    2.903176  8.827037e+06
10   4.217276  8.852179e+06
11   5.968173  8.872449e+06
12   8.256498  8.889029e+06
13  11.197244  8.902765e+06
14  14.920728  8.914271e+06
```

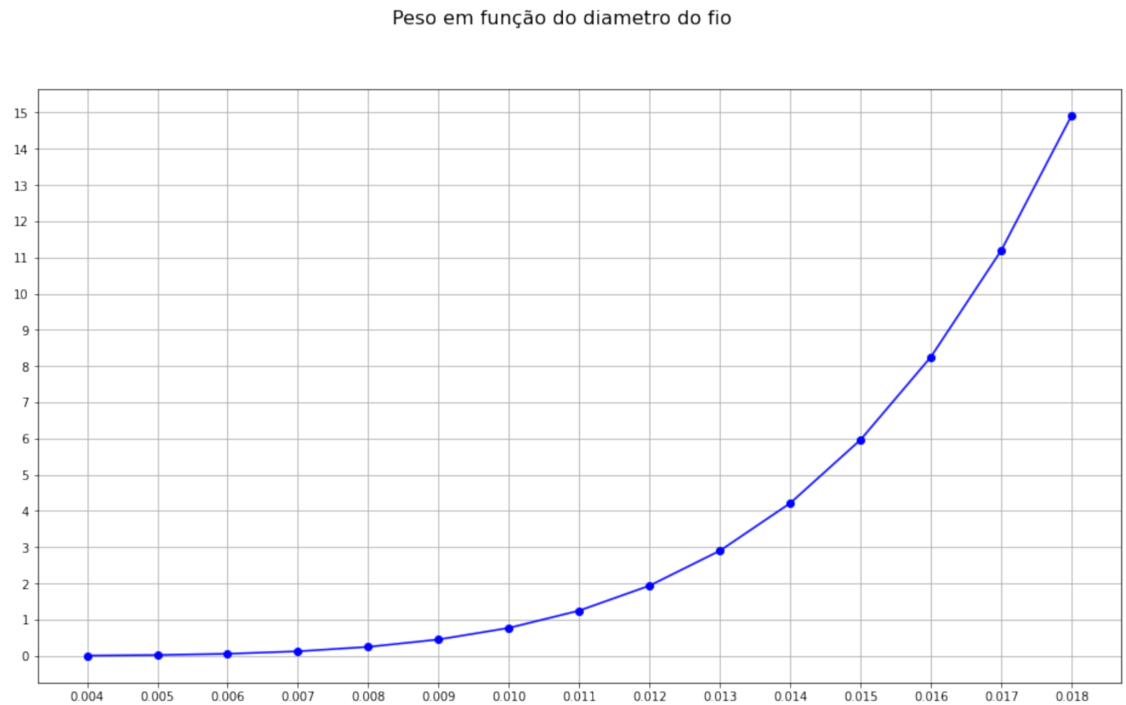
[ ]:

```
# Análise gráfica

# plotagem do peso em funcao do diametro

fig = plt.figure(figsize=[16, 9])
fig.suptitle('Peso em função do diametro do fio', fontsize=16)

# Plotando 2D

ax = fig.add_subplot(1, 1, 1)

ax.plot(d_list,
    df['P'],
    'o',
    d_list,
    df['P'],
    '-',
    color='b',
)

ax.locator_params(axis='y', nbins=30)
ax.locator_params(axis='x', nbins=30)
ax.grid()

plt.show()
```

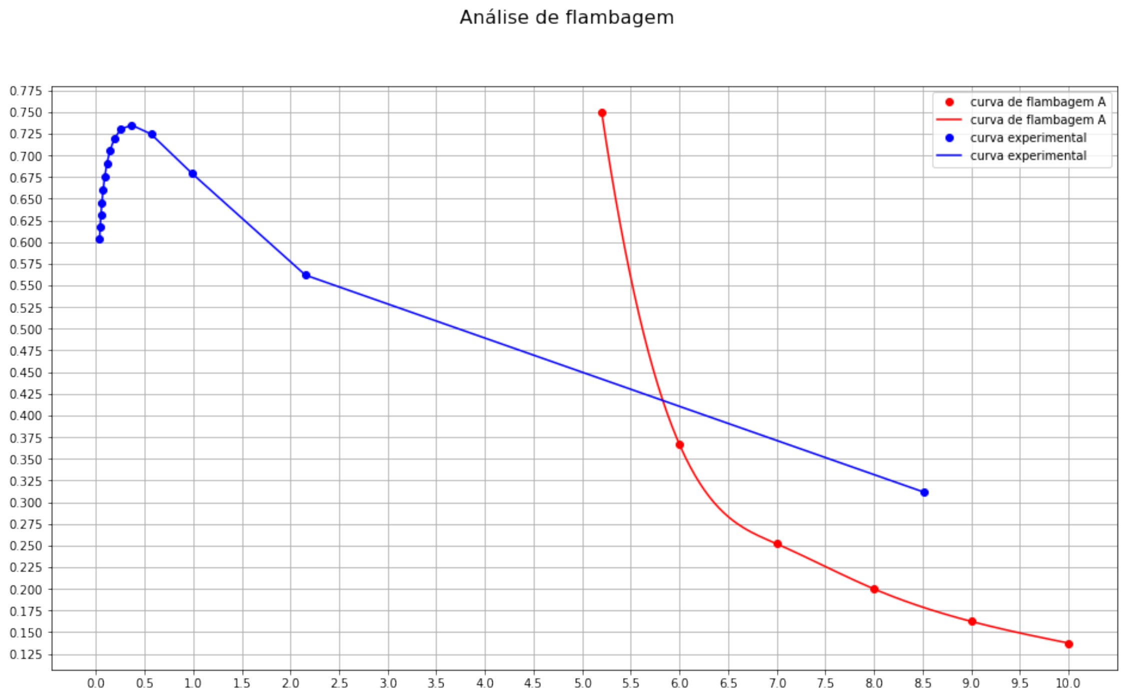
```
# análise de flambagem

fig = plt.figure(figsize=[16, 9])
fig.suptitle('Análise de flambagem', fontsize=16)


flambagem_seed = np.array((
    [5.2,0.75],
    [10,0.1375],
    [9,0.1625],
    [6,0.3667],
    [8,0.2],
    [7,0.252]
))

flambagem_eval = np.linspace(
    min(flambagem_seed[:,0]),
    max(flambagem_seed[:,0]),
    num=200
)

# Análise de flambagem

fig = plt.figure(figsize=[16, 9])
fig.suptitle('Análise de flambagem', fontsize=16)

# Plotando 2D

ax = fig.add_subplot(1, 1, 1)

f2 = interp1d(
    flambagem_seed[:,0],
    flambagem_seed[:,1],
    kind='cubic'
)

curva_A = f2(flambagem_eval)   # use interpolation function returned by␣
 ↪`interp1d`

ax.plot(flambagem_seed[:,0],
    flambagem_seed[:,1],
    'o',
    flambagem_eval,
    curva_A,
    '-',
    color='r',
    label='curva de flambagem A'
```

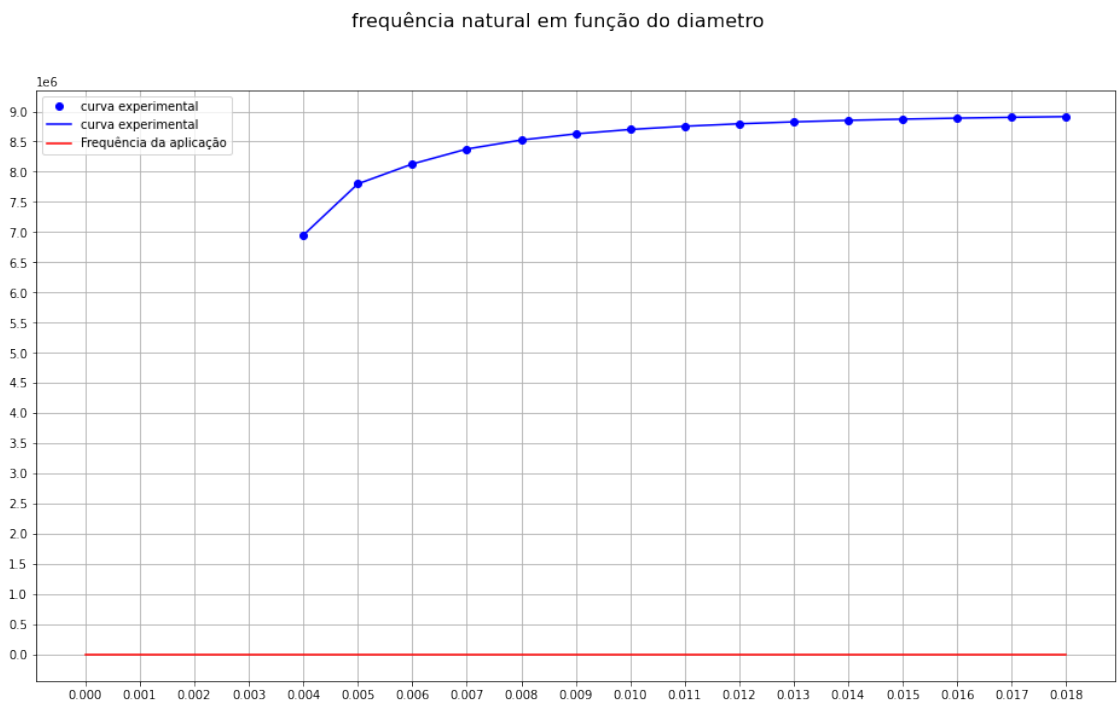
```
)

ax.plot(df['Lf/D'],
    df['delta/Lf'],
    'o',
    df['Lf/D'],
    df['delta/Lf'],
    '-',
    color='b',
    label='curva experimental'
)

ax.locator_params(axis='y', nbins=30)
ax.locator_params(axis='x', nbins=30)
ax.grid()
ax.legend()

plt.show()

# Análise de frequencia natural

fig = plt.figure(figsize=[16, 9])
fig.suptitle('frequência natural em função do diametro', fontsize=16)

# Plotando 2D

ax = fig.add_subplot(1, 1, 1)

ax.plot(d_list,
    df['fn'],
    'o',
    d_list,
    df['fn'],
    '-',
    color='b',
    label="curva experimental"
)

ax.plot([0,max(d_list)],
    [650,650],
    '-',
    color='r',
    label = 'Frequência da aplicação'
)

ax.locator_params(axis='y', nbins=30)
ax.locator_params(axis='x', nbins=30)
```

```
ax.grid()
ax.legend()

plt.show()
```




```
<Figure size 1152x648 with 0 Axes>
```


Análise de flambagem
curva de flambagem A
curva de flambagem A
curva experimental
curva experimental


frequência natural em função do diametro
1e6
curva experimental
curva experimental
Frequência da aplicação

[ ]: