lab4

June 1, 2021

[2]:
```
#!pip install transformations
from transformations import *
import os
import pandas as pd
from math import *
import numpy as np
```

0.0.1 Read Taula-DH

[10]:
```
taula = pd.read_csv("taula-DH.0", sep=',', names=[0,1,2,3])
```

0.0.2 Find 0_T_Clamp

[11]:
```
origin, xaxis, yaxis, zaxis = [0, 0, 0], [1, 0, 0], [0, 1, 0], [0, 0, 1]

Zero_T_Clamp = identity_matrix()

for i in range(0,9):
    Zero_T_Clamp = concatenate_matrices(Zero_T_Clamp,
                                        translation_matrix([taula[1][i], 0, 0]),
                                        rotation_matrix(radians(taula[0][i]),␣
 ↪xaxis),
                                        translation_matrix([0, 0, taula[2][i]]),
                                        rotation_matrix(radians(taula[3][i]),␣
 ↪zaxis)
                                        )
Zero_T_Clamp = concatenate_matrices(Zero_T_Clamp, translation_matrix([1.
 ↪56,0,0]))
print(Zero_T_Clamp)
```

```
[[ 0.50001511  0.86601668  0.          13.00005415]
 [-0.86601668  0.50001511  0.          -0.49982159]
 [ 0.          0.          1.           0.        ]
 [ 0.          0.          0.           1.        ]]
```

0.0.3 Find position of Clamp from 0

[12]:
```
Clamp_0 = np.matmul(Zero_T_Clamp, np.array([[0, 0, 0, 1]]).transpose())
Clamp_0
```

[12]:
```
array([[13.00005415],
       [-0.49982159],
       [ 0.        ],
       [ 1.        ]])
```

0.1 Exercise 2

0.1.1 Compute T and D, for each row of Taula-DH

[15]:
```
def compute_T_and_D (taula):

    T = []
    D = []

    for i in range(0,9):
        T.append(concatenate_matrices(translation_matrix([taula[1][i], 0, 0]),
                                      rotation_matrix(radians(taula[0][i]),␣
↪xaxis),
                                      translation_matrix([0, 0, taula[2][i]]),
                                      rotation_matrix(radians(taula[3][i]),␣
↪zaxis)
                                     )
                )
        D.append(np.array([[-np.sin(radians(taula[3][i])), -np.
↪cos(radians(taula[3][i])), 0, 0],
                           [np.cos(radians(taula[0][i]))*np.
↪cos(radians(taula[3][i])), -np.cos(radians(taula[0][i]))*np.
↪sin(radians(taula[3][i])), 0, 0],
                           [np.sin(radians(taula[0][i]))*np.
↪cos(radians(taula[3][i])), -np.sin(radians(taula[0][i]))*np.
↪sin(radians(taula[3][i])), 0, 0],
                           [0,0,0,0]
                          ]))
    #print(T)
    #print(D)
    return T, D

T, D = compute_T_and_D(taula)
```

0.1.2 Compute J

[16]:
```
def compute_J (T, D):
    DX = []
    T_8_9 = translation_matrix([1.56,0,0])

    DX.append(D[0] @ T[1] @ T[2] @ T[3] @ T[4] @ T[5] @ T[6] @ T[7] @ T[8] @␣
 ↪T_8_9)
    DX.append(T[0] @ D[1] @ T[2] @ T[3] @ T[4] @ T[5] @ T[6] @ T[7] @ T[8] @␣
 ↪T_8_9)
    DX.append(T[0] @ T[1] @ D[2] @ T[3] @ T[4] @ T[5] @ T[6] @ T[7] @ T[8] @␣
 ↪T_8_9)
    DX.append(T[0] @ T[1] @ T[2] @ D[3] @ T[4] @ T[5] @ T[6] @ T[7] @ T[8] @␣
 ↪T_8_9)
    DX.append(T[0] @ T[1] @ T[2] @ T[3] @ D[4] @ T[5] @ T[6] @ T[7] @ T[8] @␣
 ↪T_8_9)
    DX.append(T[0] @ T[1] @ T[2] @ T[3] @ T[4] @ D[5] @ T[6] @ T[7] @ T[8] @␣
 ↪T_8_9)
    DX.append(T[0] @ T[1] @ T[2] @ T[3] @ T[4] @ T[5] @ D[6] @ T[7] @ T[8] @␣
 ↪T_8_9)
    DX.append(T[0] @ T[1] @ T[2] @ T[3] @ T[4] @ T[5] @ T[6] @ D[7] @ T[8] @␣
 ↪T_8_9)
    DX.append(T[0] @ T[1] @ T[2] @ T[3] @ T[4] @ T[5] @ T[6] @ T[7] @ D[8] @␣
 ↪T_8_9)

    J = [[0 for x in range(9)] for y in range(3)]

    for i in range(0,9):
        J[0][i] = DX[i][0][3]
        J[1][i] = DX[i][1][3]
        J[2][i] = DX[i][0][0]

    return J

def compute_pseudoInv(J):
    J = np.array(J)
    A = J @ J.transpose()
    B = np.linalg.inv(A)

    J_psinv = J.transpose() @ B

    return J_psinv

J = compute_J(T, D)
compute_pseudoInv(J)
```

0.2 Exercise 3

[ ]:
```
delta_x = np.array([-0.10, 0, 0])
taula = pd.read_csv("taula-DH.0", sep=',', names=[0,1,2,3]);

for i in range(0,90):
    theta = [taula[3][i] for i in range(0,9)];
    T, D = compute_T_and_D(taula);
    J = compute_J(T, D);
    J_pseinv = compute_pseudoInv(J);
    delta_theta = J_pseinv @ delta_x
    theta = np.add(theta, list(map(degrees, delta_theta)))
    taula[3] = theta
    print(taula[3])
    taula.to_csv("taula-DH", sep=',', header=False, index=False)
    os.system("povray jcb.pov")
    command = f"mv jcb.png jcb_{i}.png"
    os.system(command)
```

[175]:
```
os.system("povray jcb.pov")
taula
```

[175]:

	0	1	2	3
0	0.0	0.0	0.0	82.387654
1	0.0	2.0	0.0	-27.111788
2	0.0	2.0	0.0	-34.110851
3	0.0	2.0	0.0	-16.348346
4	0.0	2.0	0.0	-16.342513
5	0.0	2.0	0.0	-14.024416
6	0.0	2.0	0.0	-9.618553
7	0.0	2.0	0.0	-3.545088
8	0.0	2.0	0.0	-21.285099

[76]:
```
taula
```

[76]:

	0	1	2	3
0	0.0	0.0	0.0	82.401
1	0.0	2.0	0.0	-27.108
2	0.0	2.0	0.0	-34.115
3	0.0	2.0	0.0	-16.356
4	0.0	2.0	0.0	-16.351
5	0.0	2.0	0.0	-14.031
6	0.0	2.0	0.0	-9.621
7	0.0	2.0	0.0	-3.542
8	0.0	2.0	0.0	-21.276

0.3 Exercise 4

0.3.1 a)

[17]:
```
delta_x = np.array([-0.10, 0, 0])
taula = pd.read_csv("taula-DH.0", sep=',', names=[0,1,2,3]);

for i in range(0,90):
    theta = [taula[3][i] for i in range(0,9)];
    T, D = compute_T_and_D(taula);
    J = compute_J(T, D);
    J[0][4] = 0
    J[1][4] = 0
    J[2][4] = 0
    J_pseinv = compute_pseudoInv(J);
    delta_theta = J_pseinv @ delta_x
    theta = np.add(theta, list(map(degrees, delta_theta)))
    taula[3] = theta
    print(taula[3])
    taula.to_csv("taula-DH", sep=',', header=False, index=False)
    os.system("povray jcb.pov")
    command = f"mv jcb.png jcb_{i}.png"
    os.system(command)
```

```
0    83.242433
1   -26.924681
2   -34.477445
3   -16.958213
4   -16.351000
5   -14.556118
6    -9.859555
7    -3.397923
8   -20.716498
Name: 3, dtype: float64
0    84.071945
1   -26.739241
2   -34.831764
3   -17.553935
4   -16.351000
5   -15.078339
6   -10.097329
7    -3.255646
8   -20.163690
Name: 3, dtype: float64
0    84.890104
1   -26.551787
2   -35.178264
3   -18.143415
```

```
4   -16.351000
5   -15.597828
6   -10.334394
7    -3.115134
8   -19.617282
Name: 3, dtype: float64
0    85.697437
1   -26.362415
2   -35.517228
3   -18.726891
4   -16.351000
5   -16.114738
6   -10.570815
7    -2.976350
8   -19.076999
Name: 3, dtype: float64
0    86.494437
1   -26.171211
2   -35.848918
3   -19.304582
4   -16.351000
5   -16.629220
6   -10.806659
7    -2.839262
8   -18.542586
Name: 3, dtype: float64
0    87.281566
1   -25.978252
2   -36.173579
3   -19.876696
4   -16.351000
5   -17.141413
6   -11.041986
7    -2.703839
8   -18.013801
Name: 3, dtype: float64
0    88.059253
1   -25.783611
2   -36.491438
3   -20.443428
4   -16.351000
5   -17.651452
6   -11.276855
7    -2.570050
8   -17.490419
Name: 3, dtype: float64
0    88.827903
1   -25.587351
```

```
2   -36.802708
3   -21.004961
4   -16.351000
5   -18.159465
6   -11.511322
7    -2.437867
8   -16.972229
Name: 3, dtype: float64
0    89.587894
1   -25.389532
2   -37.107586
3   -21.561468
4   -16.351000
5   -18.665573
6   -11.745441
7    -2.307263
8   -16.459031
Name: 3, dtype: float64
0    90.339584
1   -25.190207
2   -37.406257
3   -22.113112
4   -16.351000
5   -19.169895
6   -11.979263
7    -2.178213
8   -15.950636
Name: 3, dtype: float64
0    91.083307
1   -24.989425
2   -37.698894
3   -22.660047
4   -16.351000
5   -19.672543
6   -12.212839
7    -2.050692
8   -15.446868
Name: 3, dtype: float64
0    91.819381
1   -24.787229
2   -37.985659
3   -23.202417
4   -16.351000
5   -20.173623
6   -12.446217
7    -1.924678
8   -14.947558
Name: 3, dtype: float64
```

```
0    92.548104
1   -24.583661
2   -38.266704
3   -23.740359
4   -16.351000
5   -20.673241
6   -12.679442
7    -1.800149
8   -14.452549
Name: 3, dtype: float64
0    93.269760
1   -24.378756
2   -38.542170
3   -24.274004
4   -16.351000
5   -21.171496
6   -12.912561
7    -1.677084
8   -13.961689
Name: 3, dtype: float64
0    93.984614
1   -24.172549
2   -38.812192
3   -24.803473
4   -16.351000
5   -21.668483
6   -13.145616
7    -1.555464
8   -13.474837
Name: 3, dtype: float64
0    94.692921
1   -23.965069
2   -39.076895
3   -25.328883
4   -16.351000
5   -22.164295
6   -13.378650
7    -1.435272
8   -12.991858
Name: 3, dtype: float64
0    95.394921
1   -23.756346
2   -39.336395
3   -25.850344
4   -16.351000
5   -22.659023
6   -13.611704
7    -1.316489
```

```
8   -12.512622
Name: 3, dtype: float64
0    96.090841
1   -23.546403
2   -39.590803
3   -26.367958
4   -16.351000
5   -23.152752
6   -13.844817
7    -1.199099
8   -12.037008
Name: 3, dtype: float64
0    96.780899
1   -23.335265
2   -39.840223
3   -26.881826
4   -16.351000
5   -23.645567
6   -14.078030
7    -1.083089
8   -11.564900
Name: 3, dtype: float64
0    97.465301
1   -23.122951
2   -40.084752
3   -27.392040
4   -16.351000
5   -24.137549
6   -14.311380
7    -0.968442
8   -11.096188
Name: 3, dtype: float64
0    98.144243
1   -22.909481
2   -40.324482
3   -27.898689
4   -16.351000
5   -24.628776
6   -14.544904
7    -0.855147
8   -10.630765
Name: 3, dtype: float64
0    98.817912
1   -22.694872
2   -40.559499
3   -28.401855
4   -16.351000
5   -25.119326
```

```
6   -14.778639
7    -0.743190
8   -10.168531
Name: 3, dtype: float64
0    99.486487
1   -22.479140
2   -40.789883
3   -28.901620
4   -16.351000
5   -25.609273
6   -15.012621
7    -0.632560
8    -9.709390
Name: 3, dtype: float64
0    100.150137
1    -22.262298
2    -41.015711
3    -29.398057
4    -16.351000
5    -26.098689
6    -15.246884
7     -0.523246
8     -9.253251
Name: 3, dtype: float64
0    100.809026
1    -22.044360
2    -41.237054
3    -29.891237
4    -16.351000
5    -26.587646
6    -15.481464
7     -0.415239
8     -8.800026
Name: 3, dtype: float64
0    101.463309
1    -21.825336
2    -41.453979
3    -30.381229
4    -16.351000
5    -27.076212
6    -15.716394
7     -0.308528
8     -8.349631
Name: 3, dtype: float64
0    102.113134
1    -21.605236
2    -41.666548
3    -30.868095
```

```
4    -16.351000
5    -27.564455
6    -15.951708
7     -0.203106
8     -7.901986
Name: 3, dtype: float64
0    102.758644
1    -21.384070
2    -41.874821
3    -31.351896
4    -16.351000
5    -28.052440
6    -16.187438
7     -0.098965
8     -7.457014
Name: 3, dtype: float64
0    103.399976
1    -21.161846
2    -42.078853
3    -31.832688
4    -16.351000
5    -28.540232
6    -16.423618
7      0.003903
8     -7.014641
Name: 3, dtype: float64
0    104.037259
1    -20.938569
2    -42.278696
3    -32.310525
4    -16.351000
5    -29.027894
6    -16.660280
7      0.105502
8     -6.574798
Name: 3, dtype: float64
0    104.670620
1    -20.714247
2    -42.474397
3    -32.785457
4    -16.351000
5    -29.515488
6    -16.897455
7      0.205840
8     -6.137416
Name: 3, dtype: float64
0    105.300178
1    -20.488885
```

```
2    -42.666002
3    -33.257532
4    -16.351000
5    -30.003074
6    -17.135175
7      0.304921
8     -5.702431
Name: 3, dtype: float64
0    105.926048
1    -20.262487
2    -42.853553
3    -33.726795
4    -16.351000
5    -30.490712
6    -17.373471
7      0.402750
8     -5.269781
Name: 3, dtype: float64
0    106.548341
1    -20.035057
2    -43.037088
3    -34.193286
4    -16.351000
5    -30.978459
6    -17.612374
7      0.499329
8     -4.839406
Name: 3, dtype: float64
0    107.167164
1    -19.806597
2    -43.216645
3    -34.657046
4    -16.351000
5    -31.466374
6    -17.851915
7      0.594663
8     -4.411250
Name: 3, dtype: float64
0    107.782619
1    -19.577111
2    -43.392257
3    -35.118110
4    -16.351000
5    -31.954513
6    -18.092125
7      0.688753
8     -3.985256
Name: 3, dtype: float64
```

```
0    108.394803
1    -19.346599
2    -43.563954
3    -35.576513
4    -16.351000
5    -32.442931
6    -18.333034
7      0.781602
8     -3.561373
Name: 3, dtype: float64
0    109.003812
1    -19.115064
2    -43.731766
3    -36.032285
4    -16.351000
5    -32.931684
6    -18.574673
7      0.873211
8     -3.139550
Name: 3, dtype: float64
0    109.609735
1    -18.882506
2    -43.895719
3    -36.485456
4    -16.351000
5    -33.420824
6    -18.817071
7      0.963580
8     -2.719739
Name: 3, dtype: float64
0    110.212661
1    -18.648926
2    -44.055836
3    -36.936053
4    -16.351000
5    -33.910406
6    -19.060259
7      1.052710
8     -2.301892
Name: 3, dtype: float64
0    110.812674
1    -18.414322
2    -44.212138
3    -37.384100
4    -16.351000
5    -34.400481
6    -19.304266
7      1.140600
```

```
8     -1.885966
Name: 3, dtype: float64
0    111.409854
1    -18.178696
2    -44.364647
3    -37.829618
4    -16.351000
5    -34.891102
6    -19.549123
7      1.227249
8     -1.471917
Name: 3, dtype: float64
0    112.004279
1    -17.942045
2    -44.513378
3    -38.272627
4    -16.351000
5    -35.382319
6    -19.794860
7      1.312655
8     -1.059704
Name: 3, dtype: float64
0    112.596025
1    -17.704368
2    -44.658349
3    -38.713146
4    -16.351000
5    -35.874184
6    -20.041507
7      1.396817
8     -0.649288
Name: 3, dtype: float64
0    113.185163
1    -17.465664
2    -44.799571
3    -39.151190
4    -16.351000
5    -36.366745
6    -20.289093
7      1.479732
8     -0.240631
Name: 3, dtype: float64
0    113.771762
1    -17.225931
2    -44.937057
3    -39.586771
4    -16.351000
5    -36.860054
```

```
6    -20.537649
7      1.561396
8      0.166303
Name: 3, dtype: float64
0    114.355891
1    -16.985166
2    -45.070816
3    -40.019901
4    -16.351000
5    -37.354158
6    -20.787204
7      1.641805
8      0.571550
Name: 3, dtype: float64
0    114.937613
1    -16.743368
2    -45.200858
3    -40.450589
4    -16.351000
5    -37.849107
6    -21.037789
7      1.720956
8      0.975142
Name: 3, dtype: float64
0    115.516990
1    -16.500533
2    -45.327187
3    -40.878843
4    -16.351000
5    -38.344948
6    -21.289433
7      1.798843
8      1.377110
Name: 3, dtype: float64
0    116.094081
1    -16.256659
2    -45.449809
3    -41.304666
4    -16.351000
5    -38.841728
6    -21.542167
7      1.875461
8      1.777487
Name: 3, dtype: float64
0    116.668945
1    -16.011742
2    -45.568727
3    -41.728062
```

```
4    -16.351000
5    -39.339496
6    -21.796022
7      1.950804
8      2.176299
Name: 3, dtype: float64
0    117.241635
1    -15.765779
2    -45.683942
3    -42.149032
4    -16.351000
5    -39.838297
6    -22.051027
7      2.024866
8      2.573576
Name: 3, dtype: float64
0    117.812206
1    -15.518767
2    -45.795454
3    -42.567575
4    -16.351000
5    -40.338178
6    -22.307214
7      2.097639
8      2.969343
Name: 3, dtype: float64
0    118.380707
1    -15.270702
2    -45.903261
3    -42.983687
4    -16.351000
5    -40.839185
6    -22.564613
7      2.169115
8      3.363625
Name: 3, dtype: float64
0    118.947188
1    -15.021580
2    -46.007360
3    -43.397362
4    -16.351000
5    -41.341364
6    -22.823254
7      2.239287
8      3.756445
Name: 3, dtype: float64
0    119.511696
1    -14.771398
```

```
2    -46.107747
3    -43.808594
4    -16.351000
5    -41.844760
6    -23.083170
7      2.308145
8      4.147827
Name: 3, dtype: float64
0    120.074275
1    -14.520151
2    -46.204416
3    -44.217373
4    -16.351000
5    -42.349417
6    -23.344390
7      2.375680
8      4.537791
Name: 3, dtype: float64
0    120.634969
1    -14.267836
2    -46.297358
3    -44.623688
4    -16.351000
5    -42.855381
6    -23.606947
7      2.441883
8      4.926358
Name: 3, dtype: float64
0    121.193818
1    -14.014449
2    -46.386566
3    -45.027524
4    -16.351000
5    -43.362695
6    -23.870872
7      2.506742
8      5.313545
Name: 3, dtype: float64
0    121.750862
1    -13.759985
2    -46.472028
3    -45.428867
4    -16.351000
5    -43.871403
6    -24.136197
7      2.570247
8      5.699371
Name: 3, dtype: float64
```

```
0    122.306139
1    -13.504441
2    -46.553734
3    -45.827698
4    -16.351000
5    -44.381550
6    -24.402954
7      2.632386
8      6.083850
Name: 3, dtype: float64
0    122.859684
1    -13.247812
2    -46.631669
3    -46.223997
4    -16.351000
5    -44.893177
6    -24.671175
7      2.693147
8      6.467000
Name: 3, dtype: float64
0    123.411530
1    -12.990094
2    -46.705821
3    -46.617742
4    -16.351000
5    -45.406328
6    -24.940893
7      2.752516
8      6.848832
Name: 3, dtype: float64
0    123.961711
1    -12.731284
2    -46.776172
3    -47.008908
4    -16.351000
5    -45.921046
6    -25.212141
7      2.810480
8      7.229360
Name: 3, dtype: float64
0    124.510256
1    -12.471376
2    -46.842707
3    -47.397469
4    -16.351000
5    -46.437372
6    -25.484951
7      2.867025
```

```
8      7.608594
Name: 3, dtype: float64
0    125.057195
1    -12.210368
2    -46.905407
3    -47.783396
4    -16.351000
5    -46.955348
6    -25.759358
7      2.922135
8      7.986546
Name: 3, dtype: float64
0    125.602554
1    -11.948255
2    -46.964253
3    -48.166657
4    -16.351000
5    -47.475015
6    -26.035394
7      2.975797
8      8.363223
Name: 3, dtype: float64
0    126.146359
1    -11.685034
2    -47.019223
3    -48.547219
4    -16.351000
5    -47.996415
6    -26.313094
7      3.027992
8      8.738634
Name: 3, dtype: float64
0    126.688634
1    -11.420700
2    -47.070296
3    -48.925046
4    -16.351000
5    -48.519589
6    -26.592491
7      3.078705
8      9.112784
Name: 3, dtype: float64
0    127.229399
1    -11.155251
2    -47.117449
3    -49.300099
4    -16.351000
5    -49.044575
```

```
6    -26.873622
7      3.127917
8      9.485679
Name: 3, dtype: float64
0    127.768676
1    -10.888682
2    -47.160657
3    -49.672337
4    -16.351000
5    -49.571415
6    -27.156520
7      3.175611
8      9.857322
Name: 3, dtype: float64
0    128.306483
1    -10.620990
2    -47.199893
3    -50.041716
4    -16.351000
5    -50.100147
6    -27.441221
7      3.221768
8     10.227716
Name: 3, dtype: float64
0    128.842837
1    -10.352173
2    -47.235132
3    -50.408190
4    -16.351000
5    -50.630809
6    -27.727760
7      3.266366
8     10.596862
Name: 3, dtype: float64
0    129.377752
1    -10.082226
2    -47.266345
3    -50.771711
4    -16.351000
5    -51.163441
6    -28.016174
7      3.309387
8     10.964759
Name: 3, dtype: float64
0    129.911242
1     -9.811149
2    -47.293501
3    -51.132227
```

```
4    -16.351000
5    -51.698080
6    -28.306499
7      3.350808
8     11.331406
Name: 3, dtype: float64
0    130.443318
1     -9.538937
2    -47.316571
3    -51.489682
4    -16.351000
5    -52.234763
6    -28.598773
7      3.390608
8     11.696800
Name: 3, dtype: float64
0    130.973990
1     -9.265588
2    -47.335523
3    -51.844020
4    -16.351000
5    -52.773527
6    -28.893031
7      3.428763
8     12.060937
Name: 3, dtype: float64
0    131.503265
1     -8.991102
2    -47.350322
3    -52.195181
4    -16.351000
5    -53.314407
6    -29.189313
7      3.465250
8     12.423810
Name: 3, dtype: float64
0    132.031150
1     -8.715475
2    -47.360935
3    -52.543100
4    -16.351000
5    -53.857439
6    -29.487656
7      3.500044
8     12.785412
Name: 3, dtype: float64
0    132.557647
1     -8.438707
```

```
2    -47.367325
3    -52.887712
4    -16.351000
5    -54.402658
6    -29.788099
7      3.533119
8     13.145735
Name: 3, dtype: float64
0    133.082760
1     -8.160796
2    -47.369455
3    -53.228947
4    -16.351000
5    -54.950096
6    -30.090682
7      3.564448
8     13.504767
Name: 3, dtype: float64
0    133.606487
1     -7.881741
2    -47.367286
3    -53.566731
4    -16.351000
5    -55.499788
6    -30.395443
7      3.594005
8     13.862498
Name: 3, dtype: float64
0    134.128827
1     -7.601544
2    -47.360780
3    -53.900988
4    -16.351000
5    -56.051765
6    -30.702424
7      3.621760
8     14.218913
Name: 3, dtype: float64
0    134.649774
1     -7.320202
2    -47.349893
3    -54.231638
4    -16.351000
5    -56.606058
6    -31.011665
7      3.647685
8     14.573998
Name: 3, dtype: float64
```

```
0    135.169323
1     -7.037718
2    -47.334585
3    -54.558598
4    -16.351000
5    -57.162698
6    -31.323208
7      3.671749
8     14.927735
Name: 3, dtype: float64
0    135.687463
1     -6.754092
2    -47.314810
3    -54.881780
4    -16.351000
5    -57.721713
6    -31.637094
7      3.693919
8     15.280106
Name: 3, dtype: float64
0    136.204184
1     -6.469325
2    -47.290524
3    -55.201092
4    -16.351000
5    -58.283133
6    -31.953367
7      3.714165
8     15.631092
Name: 3, dtype: float64
0    136.719471
1     -6.183420
2    -47.261680
3    -55.516440
4    -16.351000
5    -58.846983
6    -32.272070
7      3.732452
8     15.980669
Name: 3, dtype: float64
0    137.233308
1     -5.896380
2    -47.228229
3    -55.827724
4    -16.351000
5    -59.413289
6    -32.593246
7      3.748746
```

```
8     16.328814
Name: 3, dtype: float64
0    137.745675
1     -5.608207
2    -47.190122
3    -56.134840
4    -16.351000
5    -59.982077
6    -32.916941
7      3.763010
8     16.675502
Name: 3, dtype: float64
```

[175]:
```
taula
```

[175]:

	0	1	2	3
0	0.0	0.0	0.0	82.387654
1	0.0	2.0	0.0	-27.111788
2	0.0	2.0	0.0	-34.110851
3	0.0	2.0	0.0	-16.348346
4	0.0	2.0	0.0	-16.342513
5	0.0	2.0	0.0	-14.024416
6	0.0	2.0	0.0	-9.618553
7	0.0	2.0	0.0	-3.545088
8	0.0	2.0	0.0	-21.285099

[76]:
```
taula
```

[76]:

	0	1	2	3
0	0.0	0.0	0.0	82.401
1	0.0	2.0	0.0	-27.108
2	0.0	2.0	0.0	-34.115
3	0.0	2.0	0.0	-16.356
4	0.0	2.0	0.0	-16.351
5	0.0	2.0	0.0	-14.031
6	0.0	2.0	0.0	-9.621
7	0.0	2.0	0.0	-3.542
8	0.0	2.0	0.0	-21.276