1 Выбор модели

Загружаем интересующую нас модель

```
mdl_KR5;
robot = KR5;
%Включим вывод графиков
plots = true;
```

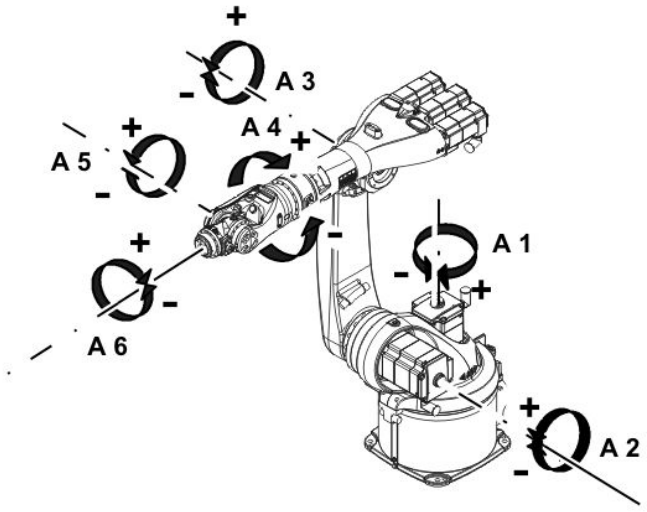
Выведем параметры Денавита - Хартенберга

```
robot.display;
```

```
robot =

Kuka KR5:: 6 axis, RRRRRR, stdDH, slowRNE
+---+-----------+-----------+-----------+-----------+-----------+
| j |     theta |         d |         a |     alpha |    offset |
+---+-----------+-----------+-----------+-----------+-----------+
|  1|         q1|        0.4|       0.18|     1.5708|          0|
|  2|         q2|      0.135|        0.6|    3.14159|          0|
|  3|         q3|      0.135|       0.12|    -1.5708|          0|
|  4|         q4|       0.62|          0|     1.5708|          0|
|  5|         q5|          0|          0|    -1.5708|          0|
|  6|         q6|          0|          0|          0|          0|
+---+-----------+-----------+-----------+-----------+-----------+
tool:    t = (0, 0, 0.115), RPY/xyz = (0, 0, 0) deg
```

Сравним конфигурацию реального робота и представление модели (ниже есть вывод графика), и убедимся, что кинематически они совпадают.



2. Задание параметров, определяющих динамику робота

Общий вес робота Kuka KR5, согласно документации, равен 127 килограмм. На основе габаритов робота на чертеже сделаем предположение о распределении общей массы по каждому из звеньев

```
robot.links(1).m = 40;
robot.links(2).m = 30;
```

```
robot.links(3).m = 30;
robot.links(4).m = 14;
robot.links(5).m = 8;
robot.links(6).m = 5;
```

Зададим центры масс для каждого звена в геометрическом центре модели

этого звена

```
robot.links(1).r = [0 0 robot.links(1).a/2];
robot.links(2).r = [0 robot.links(2).a/2 0];
robot.links(3).r = [0 robot.links(3).a/2 0];
robot.links(4).r = [0 -robot.links(4).a/2 0];
robot.links(5).r = [0 robot.links(5).a/2 0];
robot.links(6).r = [0 0 robot.links(6).a/2];
```

Выбираем тензоры инерции относительно центров масс. Предположим, что каждое звено имеет цилиндрическую форму.

```
r = 0.2; % Радиус цилиндрического звена
robot.links(1).I = [robot.links(1).m * (3 * r^2 + robot.links(1).a^2)  / 12 0 0;
                    0 robot.links(1).m * (3 * r^2 +robot.links(1).a^2)  / 12  0;
                    0 0 robot.links(1).m * robot.links(1).a^2 /2;];

robot.links(2).I = [robot.links(2).m * robot.links(2).a^2 / 12 0 0;
                    0 0 0;
                    0 0 robot.links(2).m * robot.links(2).a^2 /12;];

robot.links(3).I = [robot.links(3).m * robot.links(3).a^2 / 12 0 0;
                    0 0 0;
                    0 0 robot.links(3).m * robot.links(3).a^2 /12;];

robot.links(4).I = [robot.links(4).m * (3 * r^2 +robot.links(4).a^2)  / 12 0 0;
                    0 robot.links(4).m * (3 * r^2 +robot.links(4).a^2)  / 12  0;
                    0 0 robot.links(4).m * robot.links(4).a^2 /2;];

robot.links(5).I = [robot.links(5).m * robot.links(5).a^2 / 12 0 0;
                    0 0 0;
                    0 0 robot.links(5).m * robot.links(5).a^2 /12;];

robot.links(6).I = [robot.links(6).m * (3 * r^2 +robot.links(6).a^2)  / 12 0 0;
                    0 robot.links(6).m * (3 * r^2 +robot.links(6).a^2)  / 12  0;
                    0 0 robot.links(6).m * robot.links(6).a^2 /2;];
```

Выставим ограничения по обобщённым координатам:

```
robot.links(1).qlim = [deg2rad(-155) deg2rad(155)];
robot.links(2).qlim = [deg2rad(-180) deg2rad(65)];
```

```
robot.links(3).qlim = [deg2rad(-15) deg2rad(158)];
robot.links(4).qlim = [deg2rad(-350) deg2rad(350)];
robot.links(5).qlim = [deg2rad(-130) deg2rad(130)];
robot.links(6).qlim = [deg2rad(-350), deg2rad(350)];
```

Установим моменты инерции моторов:

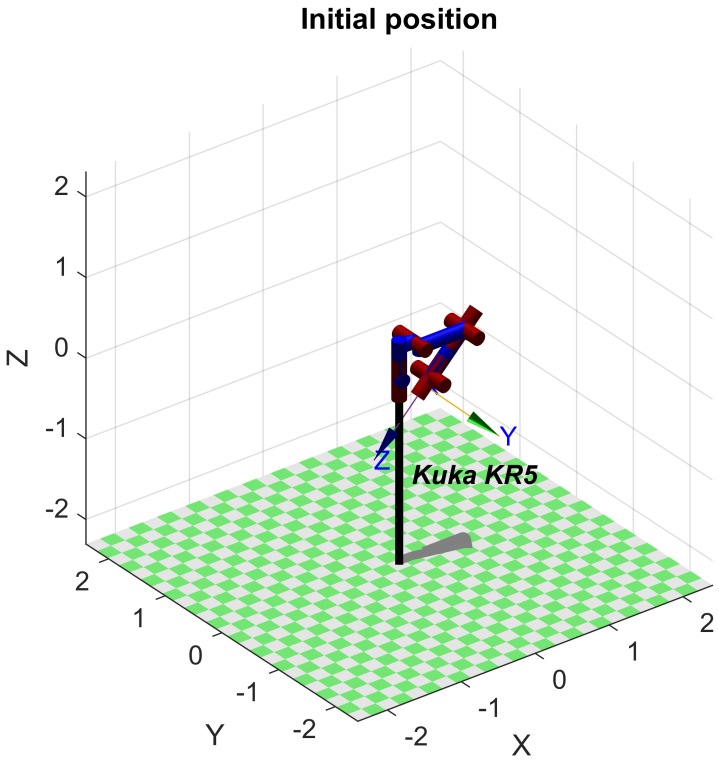
```
robot.links(1).Jm = 0.05;
robot.links(2).Jm = 0.05;
robot.links(3).Jm = 0.05;
robot.links(4).Jm = 0.05;
robot.links(5).Jm = 0.05;
robot.links(6).Jm = 0.05;
```

Передаточные числа редукторов:

```
robot.links(1).G = 1;
robot.links(2).G = 1;
robot.links(3).G = 1;
robot.links(4).G = 1;
robot.links(5).G = 1;
robot.links(6).G = 1;
```

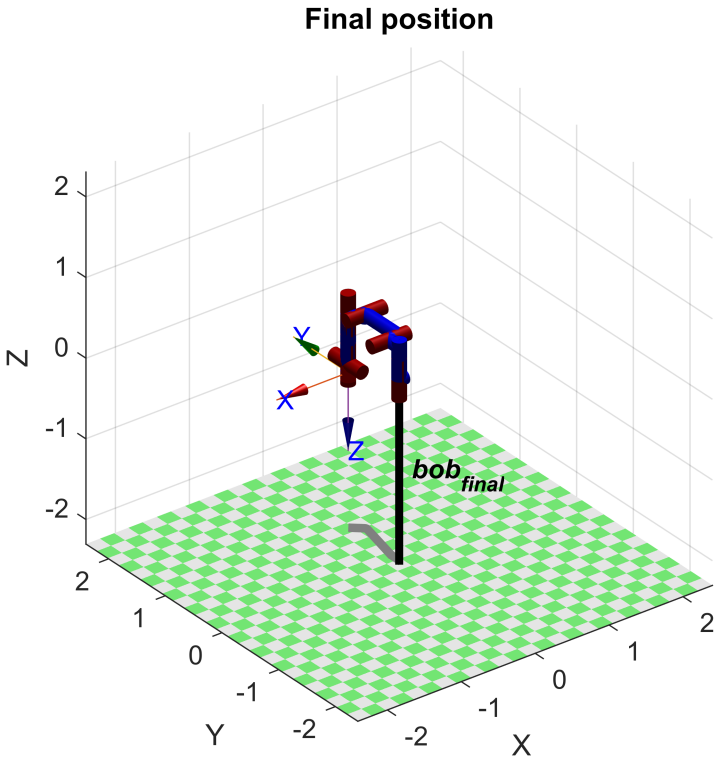
3. Зададим произвольные начальный и конечный вектор обобщённых координат робота:

```
q_init = [0 0 pi/4 0 0 -pi/4];
q_final = [pi/2 pi/4 0 -pi/2 0 0];
if plots == true
    f1 = figure;
    figure(f1)
    title("Initial position")
    robot.plot(q_init,'jointdiam', 1)
end
```



В пакете **rvctools** вывод моделей робота на график реализован таким образом, что при изменение положения робота (экземляра класса SerialLink), изменяются и положения этого объекта на всех других открытых окнах. Что бы отобразить начальное и конечное положения и анимацию, будем работать с копиями оригинального робота.

```
if plots == true
    f2 = figure;
    bob = SerialLink(robot, 'name', 'bob_{final}');
    figure(f2)
    title("Final position")
    bob.plot([pi/2 0 0 -pi/2 0 0],'jointdiam', 1)
end
```



4. Спланируем траекторию движения от начальной к конечной точкам

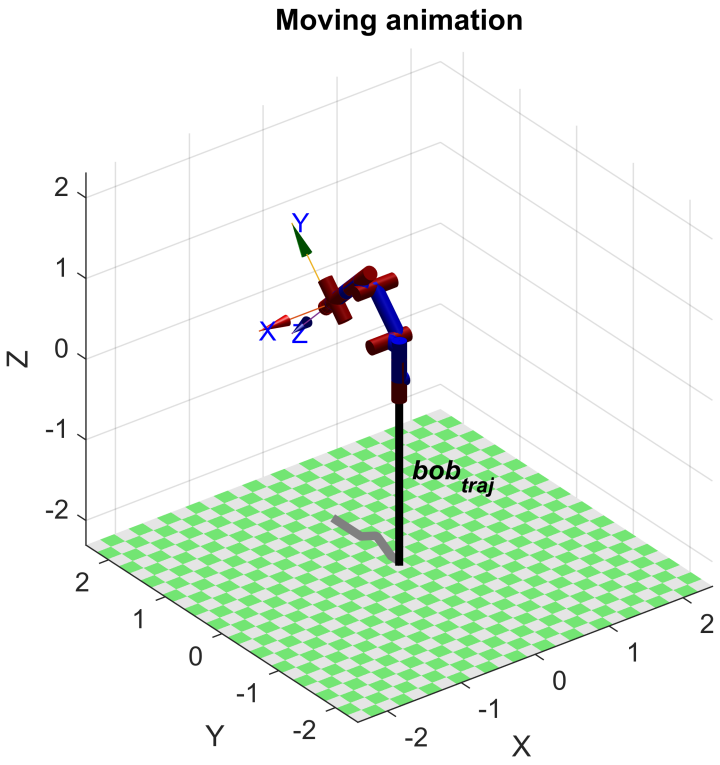
```
t = [0:.05:2];
[Q,Qt,Qtt] = jtraj(q_init, q_final, t)
```

```
Q = 41×6
         0         0    0.7854         0         0   -0.7854
    0.0002    0.0001    0.7853   -0.0002         0   -0.7853
    0.0018    0.0009    0.7845   -0.0018         0   -0.7845
    0.0059    0.0030    0.7824   -0.0059         0   -0.7824
    0.0134    0.0067    0.7787   -0.0134         0   -0.7787
    0.0252    0.0126    0.7728   -0.0252         0   -0.7728
    0.0418    0.0209    0.7645   -0.0418         0   -0.7645
    0.0636    0.0318    0.7536   -0.0636         0   -0.7536
    0.0910    0.0455    0.7399   -0.0910         0   -0.7399
    0.1240    0.0620    0.7234   -0.1240         0   -0.7234
      ⋮
Qt = 41×6
         0         0         0         0         0         0
    0.0140    0.0070   -0.0070   -0.0140         0    0.0070
    0.0532    0.0266   -0.0266   -0.0532         0    0.0266
    0.1134    0.0567   -0.0567   -0.1134         0    0.0567
    0.1909    0.0954   -0.0954   -0.1909         0    0.0954
    0.2819    0.1409   -0.1409   -0.2819         0    0.1409
    0.3830    0.1915   -0.1915   -0.3830         0    0.1915
    0.4911    0.2456   -0.2456   -0.4911         0    0.2456
    0.6032    0.3016   -0.3016   -0.6032         0    0.3016
```

```
    0.7164    0.3582   -0.3582   -0.7164         0    0.3582
      ⋮
Qtt = 41×6
         0         0         0         0         0         0
    0.5456    0.2728   -0.2728   -0.5456         0    0.2728
    1.0073    0.5036   -0.5036   -1.0073         0    0.5036
    1.3894    0.6947   -0.6947   -1.3894         0    0.6947
    1.6965    0.8482   -0.8482   -1.6965         0    0.8482
    1.9328    0.9664   -0.9664   -1.9328         0    0.9664
    2.1029    1.0515   -1.0515   -2.1029         0    1.0515
    2.2111    1.1056   -1.1056   -2.2111         0    1.1056
    2.2619    1.1310   -1.1310   -2.2619         0    1.1310
    2.2597    1.1299   -1.1299   -2.2597         0    1.1299
      ⋮
```

Функция *jtraj()* возвращает матрицы обобщённых координат, скоростей и ускорений в каждой точке траектории.

```
if plots == true
    f3 = figure;
    bob_traj = SerialLink(robot, 'name', 'bob_{traj}');
    figure(f3);
    title("Moving animation");
    bob_traj.plot(Q,'jointdiam', 1)
end
```



5. Решим обратную задачу динамики методом Ньютона - Эйлера для разных случаев:

Для решения будем использовать функцию пакета rvctools rne()

а) Ненулевые скорости и ускорения.

```
f4 = figure;
figure(f4)
tau = robot.rne(Q, Qt, Qtt)
```

```
tau = 41×6
   -0.0000  443.4085   68.6735         0         0         0
   27.0117  456.4433   63.5476   -0.1577   -0.0273    0.0136
   49.9595  467.7501   59.0066   -0.2913   -0.0504    0.0252
   69.2442  477.6528   54.8655   -0.4023   -0.0695    0.0347
   85.3042  486.4284   50.9835   -0.4925   -0.0850    0.0424
   98.5633  494.3145   47.2503   -0.5632   -0.0971    0.0483
  109.3944  501.5164   43.5781   -0.6158   -0.1062    0.0526
  118.0960  508.2131   39.8953   -0.6515   -0.1128    0.0553
  124.8797  514.5598   36.1433   -0.6709   -0.1175    0.0565
  129.8655  520.6897   32.2729   -0.6749   -0.1209    0.0565
      ⋮
```

Матрица инерций:

```
M = robot.inertia(Q)
```

```
M =
M(:,:,1) =

   48.6350    1.3677   -0.1527   -0.0990   -0.0000         0
    1.3677   37.8192   -7.0494    0.0000   -0.0500         0
   -0.1527   -7.0494   11.2996   -0.0000    0.0500         0
   -0.0990    0.0000         0    0.1900         0         0
   -0.0000   -0.0500    0.0500         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,2) =

   48.6405    1.3673   -0.1527   -0.0990    0.0000         0
    1.3673   37.8215   -7.0506    0.0000   -0.0500         0
   -0.1527   -7.0506   11.2996    0.0000    0.0500         0
   -0.0990    0.0000    0.0000    0.1900         0         0
    0.0000   -0.0500    0.0500         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,3) =

   48.6776    1.3644   -0.1526   -0.0992    0.0001         0
    1.3644   37.8374   -7.0585    0.0000   -0.0500         0
   -0.1526   -7.0585   11.2996    0.0000    0.0500         0
   -0.0992    0.0000    0.0000    0.1900         0         0
    0.0001   -0.0500    0.0500         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,4) =
```

```
   48.7733    1.3570   -0.1524   -0.0996    0.0002         0
    1.3570   37.8783   -7.0789    0.0000   -0.0500         0
   -0.1524   -7.0789   11.2996    0.0000    0.0500         0
   -0.0996    0.0000    0.0000    0.1900         0         0
    0.0002   -0.0500    0.0500         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,5) =

   48.9501    1.3434   -0.1520   -0.1003    0.0005         0
    1.3434   37.9539   -7.1168    0.0000   -0.0500         0
   -0.1520   -7.1168   11.2996    0.0000    0.0500         0
   -0.1003    0.0000    0.0000    0.1900         0         0
    0.0005   -0.0500    0.0500         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,6) =

   49.2263    1.3219   -0.1513   -0.1015    0.0009         0
    1.3219   38.0722   -7.1759    0.0000   -0.0500         0
   -0.1513   -7.1759   11.2997    0.0000    0.0500         0
   -0.1015    0.0000    0.0000    0.1900         0         0
    0.0009   -0.0500    0.0500         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,7) =

   49.6161    1.2916   -0.1502   -0.1030    0.0014         0
    1.2916   38.2394   -7.2596    0.0000   -0.0500         0
   -0.1502   -7.2596   11.2998    0.0000    0.0500         0
   -0.1030    0.0000    0.0000    0.1900         0         0
    0.0014   -0.0500    0.0500         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,8) =

   50.1299    1.2513   -0.1486   -0.1051    0.0021         0
    1.2513   38.4605   -7.3703    0.0000   -0.0499         0
   -0.1486   -7.3703   11.3002    0.0000    0.0499         0
   -0.1051    0.0000    0.0000    0.1900         0         0
    0.0021   -0.0499    0.0499         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,9) =

   50.7747    1.2005   -0.1463   -0.1076    0.0029         0
    1.2005   38.7389   -7.5098    0.0000   -0.0498         0
   -0.1463   -7.5098   11.3008    0.0000    0.0498         0
   -0.1076    0.0000    0.0000    0.1900         0         0
    0.0029   -0.0498    0.0498         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,10) =

   51.5541    1.1385   -0.1432   -0.1105    0.0038         0
    1.1385   39.0769   -7.6793    0.0000   -0.0496         0
   -0.1432   -7.6793   11.3017    0.0000    0.0496         0
```

```
   -0.1105    0.0000    0.0000    0.1900         0         0
    0.0038   -0.0496    0.0496         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,11) =

   52.4681    1.0650   -0.1390   -0.1137    0.0047         0
    1.0650   39.4755   -7.8794    0.0000   -0.0493         0
   -0.1390   -7.8794   11.3033    0.0000    0.0493         0
   -0.1137    0.0000    0.0000    0.1900         0         0
    0.0047   -0.0493    0.0493         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,12) =

   53.5135    0.9798   -0.1335   -0.1172    0.0056         0
    0.9798   39.9345   -8.1100    0.0000   -0.0489         0
   -0.1335   -8.1100   11.3055    0.0000    0.0489         0
   -0.1172    0.0000    0.0000    0.1900         0         0
    0.0056   -0.0489    0.0489         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,13) =

   54.6833    0.8831   -0.1264   -0.1208    0.0064         0
    0.8831   40.4527   -8.3706    0.0000   -0.0484         0
   -0.1264   -8.3706   11.3086    0.0000    0.0484         0
   -0.1208    0.0000    0.0000    0.1900         0         0
    0.0064   -0.0484    0.0484         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,14) =

   55.9669    0.7750   -0.1174   -0.1245    0.0070         0
    0.7750   41.0274   -8.6600    0.0000   -0.0476         0
   -0.1174   -8.6600   11.3127    0.0000    0.0476         0
   -0.1245    0.0000    0.0000    0.1900         0         0
    0.0070   -0.0476    0.0476         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,15) =

   57.3494    0.6560   -0.1063   -0.1281    0.0073         0
    0.6560   41.6549   -8.9764    0.0000   -0.0466         0
   -0.1063   -8.9764   11.3179    0.0000    0.0466         0
   -0.1281    0.0000    0.0000    0.1900         0         0
    0.0073   -0.0466    0.0466         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,16) =

   58.8116    0.5271   -0.0931   -0.1314    0.0072         0
    0.5271   42.3304   -9.3173    0.0000   -0.0454         0
   -0.0931   -9.3173   11.3242    0.0000    0.0454         0
   -0.1314    0.0000    0.0000    0.1900         0         0
    0.0072   -0.0454    0.0454         0    0.1000         0
         0         0         0         0         0    0.0500
```

M(:,:,17) =

60.3302	0.3891	-0.0777	-0.1343	0.0068	0
0.3891	43.0478	-9.6797	0.0000	-0.0439	0
-0.0777	-9.6797	11.3316	0.0000	0.0439	0
-0.1343	0.0000	0.0000	0.1900	0	0
0.0068	-0.0439	0.0439	0	0.1000	0
0	0	0	0	0	0.0500

M(:,:,18) =

61.8776	0.2436	-0.0603	-0.1367	0.0058	0
0.2436	43.8002	-10.0602	0.0000	-0.0422	0
-0.0603	-10.0602	11.3401	0.0000	0.0422	0
-0.1367	0.0000	0.0000	0.1900	0	0
0.0058	-0.0422	0.0422	0	0.1000	0
0	0	0	0	0	0.0500

M(:,:,19) =

63.4230	0.0921	-0.0413	-0.1385	0.0043	0
0.0921	44.5798	-10.4546	0.0000	-0.0401	0
-0.0413	-10.4546	11.3494	0.0000	0.0401	0
-0.1385	0.0000	0.0000	0.1900	0	0
0.0043	-0.0401	0.0401	0	0.1000	0
0	0	0	0	0	0.0500

M(:,:,20) =

64.9332	-0.0634	-0.0209	-0.1396	0.0024	0
-0.0634	45.3779	-10.8586	0.0000	-0.0379	0
-0.0209	-10.8586	11.3593	0.0000	0.0379	0
-0.1396	0.0000	0.0000	0.1900	0	0
0.0024	-0.0379	0.0379	0	0.1000	0
0	0	0	0	0	0.0500

M(:,:,21) =

66.3743	-0.2207	-0.0000	-0.1400	-0.0000	0
-0.2207	46.1855	-11.2675	0.0000	-0.0354	0
-0.0000	-11.2675	11.3696	0.0000	0.0354	0
-0.1400	0.0000	0.0000	0.1900	0	0
-0.0000	-0.0354	0.0354	0	0.1000	0
0	0	0	0	0	0.0500

M(:,:,22) =

67.7136	-0.3778	0.0209	-0.1396	-0.0028	0
-0.3778	46.9932	-11.6765	0.0000	-0.0327	0
0.0209	-11.6765	11.3799	0.0000	0.0327	0
-0.1396	0.0000	0.0000	0.1900	0	0
-0.0028	-0.0327	0.0327	0	0.1000	0
0	0	0	0	0	0.0500

M(:,:,23) =

68.9220	-0.5323	0.0413	-0.1385	-0.0058	0

```
   -0.5323   47.7917  -12.0807    0.0000   -0.0298         0
    0.0413  -12.0807   11.3898    0.0000    0.0298         0
   -0.1385    0.0000    0.0000    0.1900         0         0
   -0.0058   -0.0298    0.0298         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,24) =

   69.9759   -0.6824    0.0603   -0.1367   -0.0091         0
   -0.6824   48.5719  -12.4755    0.0000   -0.0269         0
    0.0603  -12.4755   11.3991    0.0000    0.0269         0
   -0.1367    0.0000    0.0000    0.1900         0         0
   -0.0091   -0.0269    0.0269         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,25) =

   70.8594   -0.8260    0.0777   -0.1343   -0.0124         0
   -0.8260   49.3252  -12.8564    0.0000   -0.0239         0
    0.0777  -12.8564   11.4076    0.0000    0.0239         0
   -0.1343    0.0000    0.0000    0.1900         0         0
   -0.0124   -0.0239    0.0239         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,26) =

   71.5648   -0.9616    0.0931   -0.1314   -0.0157         0
   -0.9616   50.0438  -13.2194    0.0000   -0.0209         0
    0.0931  -13.2194   11.4150    0.0000    0.0209         0
   -0.1314    0.0000    0.0000    0.1900         0         0
   -0.0157   -0.0209    0.0209         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,27) =

   72.0939   -1.0879    0.1063   -0.1281   -0.0188         0
   -1.0879   50.7205  -13.5609    0.0000   -0.0181         0
    0.1063  -13.5609   11.4213    0.0000    0.0181         0
   -0.1281    0.0000    0.0000    0.1900         0         0
   -0.0188   -0.0181    0.0181         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,28) =

   72.4570   -1.2040    0.1174   -0.1245   -0.0218         0
   -1.2040   51.3494  -13.8780    0.0000   -0.0153         0
    0.1174  -13.8780   11.4265    0.0000    0.0153         0
   -0.1245    0.0000    0.0000    0.1900         0         0
   -0.0218   -0.0153    0.0153         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,29) =

   72.6720   -1.3091    0.1264   -0.1208   -0.0244         0
   -1.3091   51.9255  -14.1680    0.0000   -0.0127         0
    0.1264  -14.1680   11.4306    0.0000    0.0127         0
   -0.1208    0.0000    0.0000    0.1900         0         0
   -0.0244   -0.0127    0.0127         0    0.1000         0
```

```
         0         0         0         0         0    0.0500


M(:,:,30) =

   72.7625   -1.4029    0.1335   -0.1172   -0.0268         0
   -1.4029   52.4450  -14.4294    0.0000   -0.0103         0
    0.1335  -14.4294   11.4337    0.0000    0.0103         0
   -0.1172    0.0000    0.0000    0.1900         0         0
   -0.0268   -0.0103    0.0103         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,31) =

   72.7556   -1.4852    0.1390   -0.1137   -0.0288         0
   -1.4852   52.9054  -14.6607    0.0000   -0.0081         0
    0.1390  -14.6607   11.4359    0.0000    0.0081         0
   -0.1137    0.0000    0.0000    0.1900         0         0
   -0.0288   -0.0081    0.0081         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,32) =

   72.6798   -1.5560    0.1432   -0.1105   -0.0305         0
   -1.5560   53.3053  -14.8614    0.0000   -0.0062         0
    0.1432  -14.8614   11.4375    0.0000    0.0062         0
   -0.1105    0.0000    0.0000    0.1900         0         0
   -0.0305   -0.0062    0.0062         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,33) =

   72.5623   -1.6155    0.1463   -0.1076   -0.0319         0
   -1.6155   53.6445  -15.0315    0.0000   -0.0045         0
    0.1463  -15.0315   11.4384    0.0000    0.0045         0
   -0.1076    0.0000    0.0000    0.1900         0         0
   -0.0319   -0.0045    0.0045         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,34) =

   72.4276   -1.6643    0.1486   -0.1051   -0.0330         0
   -1.6643   53.9239  -15.1714    0.0000   -0.0032         0
    0.1486  -15.1714   11.4390    0.0000    0.0032         0
   -0.1051    0.0000    0.0000    0.1900         0         0
   -0.0330   -0.0032    0.0032         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,35) =

   72.2954   -1.7028    0.1502   -0.1030   -0.0338         0
   -1.7028   54.1457  -15.2825    0.0000   -0.0021         0
    0.1502  -15.2825   11.4394    0.0000    0.0021         0
   -0.1030    0.0000    0.0000    0.1900         0         0
   -0.0338   -0.0021    0.0021         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,36) =
```

```
   72.1802   -1.7318    0.1513   -0.1015   -0.0344         0
   -1.7318   54.3136  -15.3666    0.0000   -0.0013         0
    0.1513  -15.3666   11.4395    0.0000    0.0013         0
   -0.1015    0.0000    0.0000    0.1900         0         0
   -0.0344   -0.0013    0.0013         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,37) =

   72.0907   -1.7523    0.1520   -0.1003   -0.0349         0
   -1.7523   54.4323  -15.4260    0.0000   -0.0007         0
    0.1520  -15.4260   11.4396    0.0000    0.0007         0
   -0.1003    0.0000    0.0000    0.1900         0         0
   -0.0349   -0.0007    0.0007         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,38) =

   72.0300   -1.7654    0.1524   -0.0996   -0.0351         0
   -1.7654   54.5083  -15.4639    0.0000   -0.0003         0
    0.1524  -15.4639   11.4396    0.0000    0.0003         0
   -0.0996    0.0000    0.0000    0.1900         0         0
   -0.0351   -0.0003    0.0003         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,39) =

   71.9960   -1.7724    0.1526   -0.0992   -0.0353         0
   -1.7724   54.5493  -15.4845    0.0000   -0.0001         0
    0.1526  -15.4845   11.4396    0.0000    0.0001         0
   -0.0992    0.0000    0.0000    0.1900         0         0
   -0.0353   -0.0001    0.0001         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,40) =

   71.9826   -1.7751    0.1527   -0.0990   -0.0353         0
   -1.7751   54.5652  -15.4924    0.0000   -0.0000         0
    0.1527  -15.4924   11.4396    0.0000    0.0000         0
   -0.0990    0.0000    0.0000    0.1900         0         0
   -0.0353   -0.0000    0.0000         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,41) =

   71.9806   -1.7755    0.1527   -0.0990   -0.0354         0
   -1.7755   54.5676  -15.4936    0.0000    0.0000         0
    0.1527  -15.4936   11.4396    0.0000   -0.0000         0
   -0.0990    0.0000    0.0000    0.1900         0         0
   -0.0354    0.0000   -0.0000         0    0.1000         0
         0         0         0         0         0    0.0500
```

Вектор гравитационных сил:

```
G = robot.gravload(Q)
```

```
G = 41×6
```

```
   -0.0000  443.4085   68.6735         0         0         0
   -0.0000  443.4576   68.6348         0         0         0
    0.0000  443.7863   68.3758         0         0         0
   -0.0000  444.6337   67.7067   -0.0000         0         0
   -0.0000  446.1960   66.4680         0         0         0
   -0.0000  448.6266   64.5278   -0.0000         0         0
    0.0000  452.0373   61.7781         0         0         0
    0.0000  456.4983   58.1332         0         0         0
    0.0000  462.0387   53.5285   -0.0000         0         0
   -0.0000  468.6472   47.9206   -0.0000         0         0
     ⋮
     ⋮
```

Матрица Кориолисовых сил

```
C = robot.coriolis(Q, Qt)
```

```
C =
C(:,:,1) =

     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0


C(:,:,2) =

    0.1640    0.1877   -0.1141   -0.0014    0.0008         0
   -0.2131    0.0700   -0.1401   -0.0000    0.0000         0
    0.1148    0.0700    0.0000    0.0000   -0.0000         0
   -0.0000    0.0000   -0.0000   -0.0000    0.0000         0
   -0.0004   -0.0000    0.0000   -0.0000   -0.0000   -0.0000
         0         0         0         0    0.0000         0


C(:,:,3) =

    0.6227    0.7123   -0.4340   -0.0052    0.0032         0
   -0.8085    0.2660   -0.5321   -0.0000    0.0000         0
    0.4369    0.2660    0.0000    0.0000   -0.0000         0
   -0.0000    0.0000   -0.0000   -0.0000   -0.0000         0
   -0.0013   -0.0000    0.0000   -0.0000    0.0000   -0.0000
   -0.0000         0    0.0000         0   -0.0000         0


C(:,:,4) =

    1.3289    1.5159   -0.9301   -0.0111    0.0068         0
   -1.7214    0.5680   -1.1360   -0.0001    0.0001         0
    0.9364    0.5678    0.0001    0.0001   -0.0001         0
   -0.0000    0.0001   -0.0001         0   -0.0000         0
   -0.0029   -0.0000    0.0000   -0.0000   -0.0000   -0.0000
         0    0.0000   -0.0000         0   -0.0000         0


C(:,:,5) =

    2.2381    2.5400   -1.5785   -0.0185    0.0114         0
   -2.8869    0.9577   -1.9150   -0.0004    0.0002         0
    1.5896    0.9570    0.0004    0.0004   -0.0002         0
```

```
   -0.0002    0.0004   -0.0004         0    0.0000         0
   -0.0049   -0.0001    0.0001   -0.0000    0.0000   -0.0000
         0   -0.0000    0.0000         0    0.0000         0


C(:,:,6) =

    3.3091    3.7253   -2.3617   -0.0267    0.0167         0
   -4.2398    1.4183   -2.8356   -0.0010    0.0006         0
    2.3794    1.4163    0.0010    0.0010   -0.0006         0
   -0.0005    0.0010   -0.0010   -0.0000         0         0
   -0.0073   -0.0003    0.0003   -0.0000   -0.0000   -0.0000
   -0.0000   -0.0000         0         0   -0.0000         0


C(:,:,7) =

    4.5033    5.0112   -3.2680   -0.0352    0.0225         0
   -5.7145    1.9346   -3.8669   -0.0022    0.0014         0
    3.2944    1.9301    0.0022    0.0022   -0.0014         0
   -0.0011    0.0022   -0.0022   -0.0000   -0.0000         0
   -0.0101   -0.0006    0.0006   -0.0000    0.0000   -0.0000
   -0.0000   -0.0000    0.0000         0   -0.0000         0


C(:,:,8) =

    5.7844    6.3366   -4.2898   -0.0433    0.0283         0
   -7.2455    2.4926   -4.9808   -0.0042    0.0027         0
    4.3276    2.4839    0.0044    0.0042   -0.0027         0
   -0.0021    0.0042   -0.0042   -0.0000   -0.0000         0
   -0.0133   -0.0012    0.0012   -0.0000    0.0000   -0.0000
    0.0000   -0.0000    0.0000         0   -0.0000         0


C(:,:,9) =

    7.1178    7.6406   -5.4224   -0.0505    0.0340         0
   -8.7676    3.0793   -6.1510   -0.0072    0.0048         0
    5.4752    3.0640    0.0076    0.0072   -0.0048         0
   -0.0036    0.0072   -0.0072   -0.0000    0.0000         0
   -0.0169   -0.0021    0.0021   -0.0000    0.0000   -0.0000
   -0.0000    0.0000    0.0000         0    0.0000         0


C(:,:,10) =

    8.4695    8.8625   -6.6617   -0.0560    0.0391         0
  -10.2165    3.6823   -7.3523   -0.0114    0.0079         0
    6.7338    3.6577    0.0123    0.0114   -0.0079         0
   -0.0056    0.0114   -0.0114   -0.0000   -0.0000         0
   -0.0207   -0.0035    0.0035   -0.0000    0.0000   -0.0000
   -0.0000    0.0000    0.0000         0   -0.0000         0


C(:,:,11) =

    9.8056    9.9430   -8.0020   -0.0596    0.0432         0
  -11.5291    4.2896   -8.5606   -0.0168    0.0122         0
    8.0983    4.2525    0.0185    0.0168   -0.0122         0
   -0.0081    0.0168   -0.0168   -0.0000   -0.0000         0
   -0.0248   -0.0054    0.0054   -0.0000    0.0000   -0.0000
   -0.0000   -0.0000    0.0000         0   -0.0000         0
```

C(:,:,12) =

11.0909	10.8249	-9.4335	-0.0608	0.0461	0
-12.6443	4.8892	-9.7521	-0.0233	0.0177	0
9.5592	4.8365	0.0263	0.0233	-0.0177	0
-0.0109	0.0233	-0.0233	0.0000	0.0000	0
-0.0290	-0.0080	0.0080	-0.0000	0.0000	-0.0000
0.0000	-0.0000	-0.0000	0	0.0000	0

C(:,:,13) =

12.2883	11.4545	-10.9395	-0.0596	0.0473	0
-13.5042	5.4694	-10.9031	-0.0309	0.0245	0
11.1000	5.3981	0.0357	0.0309	-0.0245	0
-0.0138	0.0309	-0.0309	-0.0000	0.0000	0
-0.0333	-0.0114	0.0114	-0.0000	0.0000	-0.0000
0.0000	-0.0000	-0.0000	0	0.0000	0

C(:,:,14) =

13.3583	11.7825	-12.4945	-0.0562	0.0466	0
-14.0550	6.0182	-11.9902	-0.0394	0.0327	0
12.6944	5.9258	0.0462	0.0394	-0.0327	0
-0.0164	0.0394	-0.0394	-0.0000	0.0000	0
-0.0374	-0.0154	0.0154	-0.0000	0.0000	-0.0000
0	0	0	0	0.0000	0

C(:,:,15) =

14.2588	11.7669	-14.0625	-0.0506	0.0440	0
-14.2493	6.5240	-12.9905	-0.0485	0.0422	0
14.3051	6.4090	0.0575	0.0485	-0.0422	0
-0.0184	0.0485	-0.0485	-0.0000	0.0000	0
-0.0412	-0.0201	0.0201	-0.0000	0.0000	-0.0000
0.0000	0.0000	-0.0000	0	0	0

C(:,:,16) =

14.9466	11.3750	-15.5967	-0.0434	0.0394	0
-14.0486	6.9754	-13.8819	-0.0579	0.0526	0
15.8830	6.8375	0.0689	0.0579	-0.0526	0
-0.0192	0.0579	-0.0579	0.0000	-0.0000	0
-0.0445	-0.0254	0.0254	-0.0000	-0.0000	-0.0000
0.0000	0	-0.0000	0	-0.0000	0

C(:,:,17) =

15.3791	10.5866	-17.0402	-0.0351	0.0330	0
-13.4268	7.3618	-14.6438	-0.0675	0.0636	0
17.3687	7.2022	0.0798	0.0675	-0.0636	0
-0.0187	0.0675	-0.0675	-0.0000	0.0000	0
-0.0473	-0.0311	0.0311	-0.0000	0.0000	-0.0000
-0.0000	0.0000	-0.0000	0	0.0000	0

C(:,:,18) =

15.5182	9.3978	-18.3294	-0.0261	0.0253	0

```
  -12.3739    7.6737  -15.2581   -0.0770    0.0748         0
   18.6955    7.4951    0.0893    0.0770   -0.0748         0
   -0.0165    0.0770   -0.0770   -0.0000         0         0
   -0.0494   -0.0369    0.0369   -0.0000    0.0000   -0.0000
   -0.0000   -0.0000    0.0000         0   -0.0000         0


C(:,:,19) =

   15.3346    7.8241  -19.3986   -0.0169    0.0168         0
  -10.9000    7.9030  -15.7093   -0.0863    0.0856         0
   19.7943    7.7096    0.0967    0.0863   -0.0856         0
   -0.0125    0.0863   -0.0863   -0.0000         0         0
   -0.0509   -0.0426    0.0426   -0.0000   -0.0000   -0.0000
    0.0000    0.0000   -0.0000         0         0         0


C(:,:,20) =

   14.8124    5.9031  -20.1858   -0.0081    0.0081         0
   -9.0383    8.0438  -15.9860   -0.0950    0.0956         0
   20.6004    7.8408    0.1015    0.0950   -0.0956         0
   -0.0070    0.0950   -0.0950   -0.0000    0.0000         0
   -0.0518   -0.0477    0.0477   -0.0000    0.0000   -0.0000
    0.0000    0.0000    0.0000         0    0.0000         0


C(:,:,21) =

   13.9540    3.6961  -20.6394   -0.0000   -0.0000         0
   -6.8474    8.0920  -16.0810   -0.1031    0.1041         0
   21.0606    7.8859    0.1031    0.1031   -0.1041         0
    0.0000    0.1031   -0.1031   -0.0000         0         0
   -0.0521   -0.0521    0.0521   -0.0000   -0.0000   -0.0000
   -0.0000         0         0    0.0000         0         0


C(:,:,22) =

   12.7831    1.2873  -20.7247    0.0070   -0.0070         0
   -4.4106    8.0466  -15.9917   -0.1101    0.1108         0
   21.1394    7.8436    0.1015    0.1101   -0.1108         0
    0.0081    0.1101   -0.1101   -0.0000   -0.0000         0
   -0.0518   -0.0553    0.0553   -0.0000    0.0000   -0.0000
   -0.0000   -0.0000    0.0000         0   -0.0000         0


C(:,:,23) =

   11.3454   -1.2195  -20.4283    0.0125   -0.0125         0
   -1.8331    7.9085  -15.7203   -0.1157    0.1152         0
   20.8239    7.7150    0.0967    0.1157   -0.1152         0
    0.0169    0.1157   -0.1157   -0.0000   -0.0000         0
   -0.0511   -0.0573    0.0573   -0.0000    0.0000   -0.0000
         0    0.0000   -0.0000         0   -0.0000         0


C(:,:,24) =

    9.7070   -3.7068  -19.7602    0.0165   -0.0161         0
    0.7644    7.6817  -15.2740   -0.1195    0.1172         0
   20.1263    7.5030    0.0893    0.1195   -0.1172         0
    0.0261    0.1195   -0.1195    0.0000   -0.0000         0
   -0.0499   -0.0579    0.0579   -0.0000   -0.0000   -0.0000
```

```
   -0.0000   -0.0000         0         0   -0.0000         0


C(:,:,25) =

    7.9493   -6.0513  -18.7539    0.0187   -0.0180         0
    3.2539    7.3719  -14.6640   -0.1213    0.1168         0
   19.0825    7.2123    0.0798    0.1213   -0.1168         0
    0.0351    0.1213   -0.1213    0.0000         0         0
   -0.0484   -0.0572    0.0572   -0.0000    0.0000   -0.0000
         0    0.0000   -0.0000         0   -0.0000         0


C(:,:,26) =

    6.1625   -8.1338  -17.4621    0.0192   -0.0182         0
    5.5103    6.9872  -13.9056   -0.1206    0.1139         0
   17.7485    6.8494    0.0689    0.1206   -0.1139         0
    0.0434    0.1206   -0.1206    0.0000         0         0
   -0.0463   -0.0551    0.0551   -0.0000   -0.0000   -0.0000
    0.0000    0.0000         0         0         0         0


C(:,:,27) =

    4.4369   -9.8485  -15.9517    0.0184   -0.0170         0
    7.4217    6.5371  -13.0167   -0.1175    0.1089         0
   16.1942    6.4221    0.0575    0.1175   -0.1089         0
    0.0506    0.1175   -0.1175    0.0000         0         0
   -0.0439   -0.0520    0.0520   -0.0000   -0.0000   -0.0000
         0         0         0         0         0         0


C(:,:,28) =

    2.8550  -11.1122  -14.2964    0.0164   -0.0150         0
    8.8986    6.0321  -12.0180   -0.1120    0.1020         0
   14.4962    5.9397    0.0462    0.1120   -0.1020         0
    0.0562    0.1120   -0.1120   -0.0000   -0.0000         0
   -0.0410   -0.0480    0.0480   -0.0000   -0.0000   -0.0000
         0   -0.0000    0.0000         0   -0.0000         0


C(:,:,29) =

    1.4841  -11.8710  -12.5695    0.0138   -0.0124         0
    9.8812    5.4835  -10.9314   -0.1044    0.0936         0
   12.7300    5.4122    0.0357    0.1044   -0.0936         0
    0.0596    0.1044   -0.1044         0   -0.0000         0
   -0.0376   -0.0434    0.0434   -0.0000    0.0000   -0.0000
    0.0000    0.0000   -0.0000         0   -0.0000         0


C(:,:,30) =

    0.3710  -12.1041  -10.8383    0.0109   -0.0097         0
   10.3437    4.9031   -9.7799   -0.0950    0.0842         0
   10.9640    4.8505    0.0263    0.0950   -0.0842         0
    0.0608    0.0950   -0.0950   -0.0000   -0.0000         0
   -0.0340   -0.0384    0.0384   -0.0000    0.0000   -0.0000
         0         0         0         0   -0.0000         0


C(:,:,31) =
```

```
   -0.4605  -11.8252   -9.1587    0.0081   -0.0071         0
   10.2951    4.3028   -8.5871   -0.0844    0.0741         0
    9.2550    4.2657    0.0185    0.0844   -0.0741         0
    0.0596    0.0844   -0.0844   -0.0000    0.0000         0
   -0.0300   -0.0332    0.0332   -0.0000    0.0000   -0.0000
    0.0000    0.0000    0.0000         0   -0.0000         0


C(:,:,32) =

   -1.0100  -11.0802   -7.5733    0.0056   -0.0049         0
    9.7776    3.6944   -7.3765   -0.0730    0.0636         0
    7.6454    3.6698    0.0123    0.0730   -0.0636         0
    0.0560    0.0730   -0.0730   -0.0000    0.0000         0
   -0.0259   -0.0281    0.0281   -0.0000    0.0000   -0.0000
         0    0.0000   -0.0000         0    0.0000         0


C(:,:,33) =

   -1.2984   -9.9433   -6.1111    0.0036   -0.0031         0
    8.8616    3.0900   -6.1723   -0.0612    0.0531         0
    6.1640    3.0747    0.0076    0.0612   -0.0531         0
    0.0505    0.0612   -0.0612         0   -0.0000         0
   -0.0217   -0.0231    0.0231   -0.0000   -0.0000   -0.0000
         0         0         0         0   -0.0000         0


C(:,:,34) =

   -1.3636   -8.5112   -4.7889    0.0021   -0.0018         0
    7.6406    2.5016   -4.9989   -0.0496    0.0429         0
    4.8268    2.4929    0.0044    0.0496   -0.0429         0
    0.0433    0.0496   -0.0496    0.0000   -0.0000         0
   -0.0176   -0.0184    0.0184   -0.0000   -0.0000   -0.0000
    0.0000         0   -0.0000         0   -0.0000         0


C(:,:,35) =

   -1.2561   -6.8961   -3.6146    0.0011   -0.0009         0
    6.2235    1.9418   -3.8814   -0.0385    0.0332         0
    3.6409    1.9373    0.0022    0.0385   -0.0332         0
    0.0352    0.0385   -0.0385   -0.0000    0.0000         0
   -0.0137   -0.0141    0.0141   -0.0000   -0.0000   -0.0000
    0.0000   -0.0000   -0.0000         0    0.0000         0


C(:,:,36) =

   -1.0327   -5.2190   -2.5910    0.0005   -0.0004         0
    4.7276    1.4237   -2.8464   -0.0282    0.0243         0
    2.6087    1.4217    0.0010    0.0282   -0.0243         0
    0.0267    0.0282   -0.0282   -0.0000    0.0000         0
   -0.0100   -0.0102    0.0102   -0.0000    0.0000   -0.0000
   -0.0000   -0.0000         0         0    0.0000         0


C(:,:,37) =

   -0.7516   -3.6029   -1.7207    0.0002   -0.0002         0
    3.2719    0.9614   -1.9225   -0.0190    0.0164         0
    1.7319    0.9607    0.0004    0.0190   -0.0164         0
```

```
    0.0185    0.0190   -0.0190         0         0         0
   -0.0068   -0.0068    0.0068   -0.0000   -0.0000   -0.0000
   -0.0000   -0.0000    0.0000         0    0.0000         0


C(:,:,38) =

   -0.4665   -2.1671   -1.0094    0.0000   -0.0000         0
    1.9711    0.5703   -1.1405   -0.0113    0.0097         0
    1.0158    0.5701    0.0001    0.0113   -0.0097         0
    0.0111    0.0113   -0.0113   -0.0000    0.0000         0
   -0.0040   -0.0040    0.0040   -0.0000   -0.0000   -0.0000
    0.0000         0   -0.0000         0    0.0000         0


C(:,:,39) =

   -0.2238   -1.0226   -0.4699    0.0000   -0.0000         0
    0.9309    0.2671   -0.5342   -0.0053    0.0045         0
    0.4728    0.2671    0.0000    0.0053   -0.0045         0
    0.0052    0.0053   -0.0053         0    0.0000         0
   -0.0019   -0.0019    0.0019   -0.0000    0.0000   -0.0000
    0.0000   -0.0000   -0.0000         0    0.0000         0


C(:,:,40) =

   -0.0594   -0.2700   -0.1234    0.0000   -0.0000         0
    0.2458    0.0703   -0.1406   -0.0014    0.0012         0
    0.1242    0.0703    0.0000    0.0014   -0.0012         0
    0.0014    0.0014   -0.0014         0         0         0
   -0.0005   -0.0005    0.0005   -0.0000   -0.0000   -0.0000
         0         0         0         0   -0.0000         0


C(:,:,41) =

     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
```

```
subplot(3,1,1);
plot(t, tau(:,1:6)); xlabel('Time (s)'); ylabel('Joint torque (Nm)');
legend(["Link 1","Link 2","Link 3","Link 4","Link 5","Link 6"]);
title("$\dot{q} \neq 0, \ddot{q} \neq 0$", 'Interpreter','latex');
```

б) Ненулевые скорости и пренебрежимо малые ускорения.

```
tau = robot.rne(Q, Qt, Qtt.*1e-15)
```

```
tau = 41×6
   -0.0000  443.4085   68.6735         0         0         0
    0.0044  443.4561   68.6369    0.0000   -0.0000    0.0000
    0.0639  443.7645   68.4061    0.0000   -0.0001    0.0000
    0.2906  444.5351   67.8450    0.0000   -0.0003    0.0000
```

```
    0.8237  445.9192   66.8626    0.0000   -0.0009    0.0000
    1.7981  448.0313   65.3977    0.0001   -0.0021    0.0000
    3.3240  450.9604   63.4083    0.0004   -0.0041    0.0000
    5.4717  454.7771   60.8654    0.0010   -0.0071    0.0000
    8.2635  459.5383   57.7485    0.0022   -0.0114    0.0000
   11.6691  465.2887   54.0426    0.0041   -0.0174    0.0000
      ⋮
      ⋮
```

Матрица инерций:

```
M = robot.inertia(Q)
```

```
M =
M(:,:,1) =

   48.6350    1.3677   -0.1527   -0.0990   -0.0000         0
    1.3677   37.8192   -7.0494    0.0000   -0.0500         0
   -0.1527   -7.0494   11.2996   -0.0000    0.0500         0
   -0.0990    0.0000         0    0.1900         0         0
   -0.0000   -0.0500    0.0500         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,2) =

   48.6405    1.3673   -0.1527   -0.0990    0.0000         0
    1.3673   37.8215   -7.0506    0.0000   -0.0500         0
   -0.1527   -7.0506   11.2996    0.0000    0.0500         0
   -0.0990    0.0000    0.0000    0.1900         0         0
    0.0000   -0.0500    0.0500         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,3) =

   48.6776    1.3644   -0.1526   -0.0992    0.0001         0
    1.3644   37.8374   -7.0585    0.0000   -0.0500         0
   -0.1526   -7.0585   11.2996    0.0000    0.0500         0
   -0.0992    0.0000    0.0000    0.1900         0         0
    0.0001   -0.0500    0.0500         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,4) =

   48.7733    1.3570   -0.1524   -0.0996    0.0002         0
    1.3570   37.8783   -7.0789    0.0000   -0.0500         0
   -0.1524   -7.0789   11.2996    0.0000    0.0500         0
   -0.0996    0.0000    0.0000    0.1900         0         0
    0.0002   -0.0500    0.0500         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,5) =

   48.9501    1.3434   -0.1520   -0.1003    0.0005         0
    1.3434   37.9539   -7.1168    0.0000   -0.0500         0
   -0.1520   -7.1168   11.2996    0.0000    0.0500         0
   -0.1003    0.0000    0.0000    0.1900         0         0
    0.0005   -0.0500    0.0500         0    0.1000         0
         0         0         0         0         0    0.0500
```

M(:,:,6) =

49.2263	1.3219	-0.1513	-0.1015	0.0009	0
1.3219	38.0722	-7.1759	0.0000	-0.0500	0
-0.1513	-7.1759	11.2997	0.0000	0.0500	0
-0.1015	0.0000	0.0000	0.1900	0	0
0.0009	-0.0500	0.0500	0	0.1000	0
0	0	0	0	0	0.0500

M(:,:,7) =

49.6161	1.2916	-0.1502	-0.1030	0.0014	0
1.2916	38.2394	-7.2596	0.0000	-0.0500	0
-0.1502	-7.2596	11.2998	0.0000	0.0500	0
-0.1030	0.0000	0.0000	0.1900	0	0
0.0014	-0.0500	0.0500	0	0.1000	0
0	0	0	0	0	0.0500

M(:,:,8) =

50.1299	1.2513	-0.1486	-0.1051	0.0021	0
1.2513	38.4605	-7.3703	0.0000	-0.0499	0
-0.1486	-7.3703	11.3002	0.0000	0.0499	0
-0.1051	0.0000	0.0000	0.1900	0	0
0.0021	-0.0499	0.0499	0	0.1000	0
0	0	0	0	0	0.0500

M(:,:,9) =

50.7747	1.2005	-0.1463	-0.1076	0.0029	0
1.2005	38.7389	-7.5098	0.0000	-0.0498	0
-0.1463	-7.5098	11.3008	0.0000	0.0498	0
-0.1076	0.0000	0.0000	0.1900	0	0
0.0029	-0.0498	0.0498	0	0.1000	0
0	0	0	0	0	0.0500

M(:,:,10) =

51.5541	1.1385	-0.1432	-0.1105	0.0038	0
1.1385	39.0769	-7.6793	0.0000	-0.0496	0
-0.1432	-7.6793	11.3017	0.0000	0.0496	0
-0.1105	0.0000	0.0000	0.1900	0	0
0.0038	-0.0496	0.0496	0	0.1000	0
0	0	0	0	0	0.0500

M(:,:,11) =

52.4681	1.0650	-0.1390	-0.1137	0.0047	0
1.0650	39.4755	-7.8794	0.0000	-0.0493	0
-0.1390	-7.8794	11.3033	0.0000	0.0493	0
-0.1137	0.0000	0.0000	0.1900	0	0
0.0047	-0.0493	0.0493	0	0.1000	0
0	0	0	0	0	0.0500

M(:,:,12) =

53.5135	0.9798	-0.1335	-0.1172	0.0056	0

```
    0.9798   39.9345   -8.1100    0.0000   -0.0489         0
   -0.1335   -8.1100   11.3055    0.0000    0.0489         0
   -0.1172    0.0000    0.0000    0.1900         0         0
    0.0056   -0.0489    0.0489         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,13) =

   54.6833    0.8831   -0.1264   -0.1208    0.0064         0
    0.8831   40.4527   -8.3706    0.0000   -0.0484         0
   -0.1264   -8.3706   11.3086    0.0000    0.0484         0
   -0.1208    0.0000    0.0000    0.1900         0         0
    0.0064   -0.0484    0.0484         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,14) =

   55.9669    0.7750   -0.1174   -0.1245    0.0070         0
    0.7750   41.0274   -8.6600    0.0000   -0.0476         0
   -0.1174   -8.6600   11.3127    0.0000    0.0476         0
   -0.1245    0.0000    0.0000    0.1900         0         0
    0.0070   -0.0476    0.0476         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,15) =

   57.3494    0.6560   -0.1063   -0.1281    0.0073         0
    0.6560   41.6549   -8.9764    0.0000   -0.0466         0
   -0.1063   -8.9764   11.3179    0.0000    0.0466         0
   -0.1281    0.0000    0.0000    0.1900         0         0
    0.0073   -0.0466    0.0466         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,16) =

   58.8116    0.5271   -0.0931   -0.1314    0.0072         0
    0.5271   42.3304   -9.3173    0.0000   -0.0454         0
   -0.0931   -9.3173   11.3242    0.0000    0.0454         0
   -0.1314    0.0000    0.0000    0.1900         0         0
    0.0072   -0.0454    0.0454         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,17) =

   60.3302    0.3891   -0.0777   -0.1343    0.0068         0
    0.3891   43.0478   -9.6797    0.0000   -0.0439         0
   -0.0777   -9.6797   11.3316    0.0000    0.0439         0
   -0.1343    0.0000    0.0000    0.1900         0         0
    0.0068   -0.0439    0.0439         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,18) =

   61.8776    0.2436   -0.0603   -0.1367    0.0058         0
    0.2436   43.8002  -10.0602    0.0000   -0.0422         0
   -0.0603  -10.0602   11.3401    0.0000    0.0422         0
   -0.1367    0.0000    0.0000    0.1900         0         0
    0.0058   -0.0422    0.0422         0    0.1000         0
```

```
         0         0         0         0         0    0.0500


M(:,:,19) =

   63.4230    0.0921   -0.0413   -0.1385    0.0043         0
    0.0921   44.5798  -10.4546    0.0000   -0.0401         0
   -0.0413  -10.4546   11.3494    0.0000    0.0401         0
   -0.1385    0.0000    0.0000    0.1900         0         0
    0.0043   -0.0401    0.0401         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,20) =

   64.9332   -0.0634   -0.0209   -0.1396    0.0024         0
   -0.0634   45.3779  -10.8586    0.0000   -0.0379         0
   -0.0209  -10.8586   11.3593    0.0000    0.0379         0
   -0.1396    0.0000    0.0000    0.1900         0         0
    0.0024   -0.0379    0.0379         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,21) =

   66.3743   -0.2207   -0.0000   -0.1400   -0.0000         0
   -0.2207   46.1855  -11.2675    0.0000   -0.0354         0
   -0.0000  -11.2675   11.3696    0.0000    0.0354         0
   -0.1400    0.0000    0.0000    0.1900         0         0
   -0.0000   -0.0354    0.0354         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,22) =

   67.7136   -0.3778    0.0209   -0.1396   -0.0028         0
   -0.3778   46.9932  -11.6765    0.0000   -0.0327         0
    0.0209  -11.6765   11.3799    0.0000    0.0327         0
   -0.1396    0.0000    0.0000    0.1900         0         0
   -0.0028   -0.0327    0.0327         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,23) =

   68.9220   -0.5323    0.0413   -0.1385   -0.0058         0
   -0.5323   47.7917  -12.0807    0.0000   -0.0298         0
    0.0413  -12.0807   11.3898    0.0000    0.0298         0
   -0.1385    0.0000    0.0000    0.1900         0         0
   -0.0058   -0.0298    0.0298         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,24) =

   69.9759   -0.6824    0.0603   -0.1367   -0.0091         0
   -0.6824   48.5719  -12.4755    0.0000   -0.0269         0
    0.0603  -12.4755   11.3991    0.0000    0.0269         0
   -0.1367    0.0000    0.0000    0.1900         0         0
   -0.0091   -0.0269    0.0269         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,25) =
```

```
   70.8594   -0.8260    0.0777   -0.1343   -0.0124         0
   -0.8260   49.3252  -12.8564    0.0000   -0.0239         0
    0.0777  -12.8564   11.4076    0.0000    0.0239         0
   -0.1343    0.0000    0.0000    0.1900         0         0
   -0.0124   -0.0239    0.0239         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,26) =

   71.5648   -0.9616    0.0931   -0.1314   -0.0157         0
   -0.9616   50.0438  -13.2194    0.0000   -0.0209         0
    0.0931  -13.2194   11.4150    0.0000    0.0209         0
   -0.1314    0.0000    0.0000    0.1900         0         0
   -0.0157   -0.0209    0.0209         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,27) =

   72.0939   -1.0879    0.1063   -0.1281   -0.0188         0
   -1.0879   50.7205  -13.5609    0.0000   -0.0181         0
    0.1063  -13.5609   11.4213    0.0000    0.0181         0
   -0.1281    0.0000    0.0000    0.1900         0         0
   -0.0188   -0.0181    0.0181         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,28) =

   72.4570   -1.2040    0.1174   -0.1245   -0.0218         0
   -1.2040   51.3494  -13.8780    0.0000   -0.0153         0
    0.1174  -13.8780   11.4265    0.0000    0.0153         0
   -0.1245    0.0000    0.0000    0.1900         0         0
   -0.0218   -0.0153    0.0153         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,29) =

   72.6720   -1.3091    0.1264   -0.1208   -0.0244         0
   -1.3091   51.9255  -14.1680    0.0000   -0.0127         0
    0.1264  -14.1680   11.4306    0.0000    0.0127         0
   -0.1208    0.0000    0.0000    0.1900         0         0
   -0.0244   -0.0127    0.0127         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,30) =

   72.7625   -1.4029    0.1335   -0.1172   -0.0268         0
   -1.4029   52.4450  -14.4294    0.0000   -0.0103         0
    0.1335  -14.4294   11.4337    0.0000    0.0103         0
   -0.1172    0.0000    0.0000    0.1900         0         0
   -0.0268   -0.0103    0.0103         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,31) =

   72.7556   -1.4852    0.1390   -0.1137   -0.0288         0
   -1.4852   52.9054  -14.6607    0.0000   -0.0081         0
    0.1390  -14.6607   11.4359    0.0000    0.0081         0
```

```
   -0.1137    0.0000    0.0000    0.1900         0         0
   -0.0288   -0.0081    0.0081         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,32) =

   72.6798   -1.5560    0.1432   -0.1105   -0.0305         0
   -1.5560   53.3053  -14.8614    0.0000   -0.0062         0
    0.1432  -14.8614   11.4375    0.0000    0.0062         0
   -0.1105    0.0000    0.0000    0.1900         0         0
   -0.0305   -0.0062    0.0062         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,33) =

   72.5623   -1.6155    0.1463   -0.1076   -0.0319         0
   -1.6155   53.6445  -15.0315    0.0000   -0.0045         0
    0.1463  -15.0315   11.4384    0.0000    0.0045         0
   -0.1076    0.0000    0.0000    0.1900         0         0
   -0.0319   -0.0045    0.0045         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,34) =

   72.4276   -1.6643    0.1486   -0.1051   -0.0330         0
   -1.6643   53.9239  -15.1714    0.0000   -0.0032         0
    0.1486  -15.1714   11.4390    0.0000    0.0032         0
   -0.1051    0.0000    0.0000    0.1900         0         0
   -0.0330   -0.0032    0.0032         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,35) =

   72.2954   -1.7028    0.1502   -0.1030   -0.0338         0
   -1.7028   54.1457  -15.2825    0.0000   -0.0021         0
    0.1502  -15.2825   11.4394    0.0000    0.0021         0
   -0.1030    0.0000    0.0000    0.1900         0         0
   -0.0338   -0.0021    0.0021         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,36) =

   72.1802   -1.7318    0.1513   -0.1015   -0.0344         0
   -1.7318   54.3136  -15.3666    0.0000   -0.0013         0
    0.1513  -15.3666   11.4395    0.0000    0.0013         0
   -0.1015    0.0000    0.0000    0.1900         0         0
   -0.0344   -0.0013    0.0013         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,37) =

   72.0907   -1.7523    0.1520   -0.1003   -0.0349         0
   -1.7523   54.4323  -15.4260    0.0000   -0.0007         0
    0.1520  -15.4260   11.4396    0.0000    0.0007         0
   -0.1003    0.0000    0.0000    0.1900         0         0
   -0.0349   -0.0007    0.0007         0    0.1000         0
         0         0         0         0         0    0.0500
```

```
M(:,:,38) =

   72.0300   -1.7654    0.1524   -0.0996   -0.0351         0
   -1.7654   54.5083  -15.4639    0.0000   -0.0003         0
    0.1524  -15.4639   11.4396    0.0000    0.0003         0
   -0.0996    0.0000    0.0000    0.1900         0         0
   -0.0351   -0.0003    0.0003         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,39) =

   71.9960   -1.7724    0.1526   -0.0992   -0.0353         0
   -1.7724   54.5493  -15.4845    0.0000   -0.0001         0
    0.1526  -15.4845   11.4396    0.0000    0.0001         0
   -0.0992    0.0000    0.0000    0.1900         0         0
   -0.0353   -0.0001    0.0001         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,40) =

   71.9826   -1.7751    0.1527   -0.0990   -0.0353         0
   -1.7751   54.5652  -15.4924    0.0000   -0.0000         0
    0.1527  -15.4924   11.4396    0.0000    0.0000         0
   -0.0990    0.0000    0.0000    0.1900         0         0
   -0.0353   -0.0000    0.0000         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,41) =

   71.9806   -1.7755    0.1527   -0.0990   -0.0354         0
   -1.7755   54.5676  -15.4936    0.0000    0.0000         0
    0.1527  -15.4936   11.4396    0.0000   -0.0000         0
   -0.0990    0.0000    0.0000    0.1900         0         0
   -0.0354    0.0000   -0.0000         0    0.1000         0
         0         0         0         0         0    0.0500
```

Вектор гравитационных сил:

```
G = robot.gravload(Q)
```

```
G = 41×6
   -0.0000  443.4085   68.6735         0         0         0
   -0.0000  443.4576   68.6348         0         0         0
    0.0000  443.7863   68.3758         0         0         0
   -0.0000  444.6337   67.7067   -0.0000         0         0
   -0.0000  446.1960   66.4680         0         0         0
   -0.0000  448.6266   64.5278   -0.0000         0         0
    0.0000  452.0373   61.7781         0         0         0
    0.0000  456.4983   58.1332         0         0         0
    0.0000  462.0387   53.5285   -0.0000         0         0
   -0.0000  468.6472   47.9206   -0.0000         0         0
     ⋮
```

Матрица Кориолисовых сил

```
C = robot.coriolis(Q, Qt)
```

```
C =
C(:,:,1) =

     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0


C(:,:,2) =

    0.1640    0.1877   -0.1141   -0.0014    0.0008         0
   -0.2131    0.0700   -0.1401   -0.0000    0.0000         0
    0.1148    0.0700    0.0000    0.0000   -0.0000         0
   -0.0000    0.0000   -0.0000   -0.0000    0.0000         0
   -0.0004   -0.0000    0.0000   -0.0000   -0.0000   -0.0000
         0         0         0         0    0.0000         0


C(:,:,3) =

    0.6227    0.7123   -0.4340   -0.0052    0.0032         0
   -0.8085    0.2660   -0.5321   -0.0000    0.0000         0
    0.4369    0.2660    0.0000    0.0000   -0.0000         0
   -0.0000    0.0000   -0.0000   -0.0000   -0.0000         0
   -0.0013   -0.0000    0.0000   -0.0000    0.0000   -0.0000
   -0.0000         0    0.0000         0   -0.0000         0


C(:,:,4) =

    1.3289    1.5159   -0.9301   -0.0111    0.0068         0
   -1.7214    0.5680   -1.1360   -0.0001    0.0001         0
    0.9364    0.5678    0.0001    0.0001   -0.0001         0
   -0.0000    0.0001   -0.0001         0   -0.0000         0
   -0.0029   -0.0000    0.0000   -0.0000   -0.0000   -0.0000
         0    0.0000   -0.0000         0   -0.0000         0


C(:,:,5) =

    2.2381    2.5400   -1.5785   -0.0185    0.0114         0
   -2.8869    0.9577   -1.9150   -0.0004    0.0002         0
    1.5896    0.9570    0.0004    0.0004   -0.0002         0
   -0.0002    0.0004   -0.0004         0    0.0000         0
   -0.0049   -0.0001    0.0001   -0.0000    0.0000   -0.0000
         0   -0.0000    0.0000         0    0.0000         0


C(:,:,6) =

    3.3091    3.7253   -2.3617   -0.0267    0.0167         0
   -4.2398    1.4183   -2.8356   -0.0010    0.0006         0
    2.3794    1.4163    0.0010    0.0010   -0.0006         0
   -0.0005    0.0010   -0.0010   -0.0000         0         0
   -0.0073   -0.0003    0.0003   -0.0000   -0.0000   -0.0000
   -0.0000   -0.0000         0         0   -0.0000         0


C(:,:,7) =

    4.5033    5.0112   -3.2680   -0.0352    0.0225         0
```

```
   -5.7145    1.9346   -3.8669   -0.0022    0.0014         0
    3.2944    1.9301    0.0022    0.0022   -0.0014         0
   -0.0011    0.0022   -0.0022   -0.0000   -0.0000         0
   -0.0101   -0.0006    0.0006   -0.0000    0.0000   -0.0000
   -0.0000   -0.0000    0.0000         0   -0.0000         0


C(:,:,8) =

    5.7844    6.3366   -4.2898   -0.0433    0.0283         0
   -7.2455    2.4926   -4.9808   -0.0042    0.0027         0
    4.3276    2.4839    0.0044    0.0042   -0.0027         0
   -0.0021    0.0042   -0.0042   -0.0000   -0.0000         0
   -0.0133   -0.0012    0.0012   -0.0000    0.0000   -0.0000
    0.0000   -0.0000    0.0000         0   -0.0000         0


C(:,:,9) =

    7.1178    7.6406   -5.4224   -0.0505    0.0340         0
   -8.7676    3.0793   -6.1510   -0.0072    0.0048         0
    5.4752    3.0640    0.0076    0.0072   -0.0048         0
   -0.0036    0.0072   -0.0072   -0.0000    0.0000         0
   -0.0169   -0.0021    0.0021   -0.0000    0.0000   -0.0000
   -0.0000    0.0000    0.0000         0    0.0000         0


C(:,:,10) =

    8.4695    8.8625   -6.6617   -0.0560    0.0391         0
  -10.2165    3.6823   -7.3523   -0.0114    0.0079         0
    6.7338    3.6577    0.0123    0.0114   -0.0079         0
   -0.0056    0.0114   -0.0114   -0.0000   -0.0000         0
   -0.0207   -0.0035    0.0035   -0.0000    0.0000   -0.0000
   -0.0000    0.0000    0.0000         0   -0.0000         0


C(:,:,11) =

    9.8056    9.9430   -8.0020   -0.0596    0.0432         0
  -11.5291    4.2896   -8.5606   -0.0168    0.0122         0
    8.0983    4.2525    0.0185    0.0168   -0.0122         0
   -0.0081    0.0168   -0.0168   -0.0000   -0.0000         0
   -0.0248   -0.0054    0.0054   -0.0000    0.0000   -0.0000
   -0.0000   -0.0000    0.0000         0   -0.0000         0


C(:,:,12) =

   11.0909   10.8249   -9.4335   -0.0608    0.0461         0
  -12.6443    4.8892   -9.7521   -0.0233    0.0177         0
    9.5592    4.8365    0.0263    0.0233   -0.0177         0
   -0.0109    0.0233   -0.0233    0.0000    0.0000         0
   -0.0290   -0.0080    0.0080   -0.0000    0.0000   -0.0000
    0.0000   -0.0000   -0.0000         0    0.0000         0


C(:,:,13) =

   12.2883   11.4545  -10.9395   -0.0596    0.0473         0
  -13.5042    5.4694  -10.9031   -0.0309    0.0245         0
   11.1000    5.3981    0.0357    0.0309   -0.0245         0
   -0.0138    0.0309   -0.0309   -0.0000    0.0000         0
   -0.0333   -0.0114    0.0114   -0.0000    0.0000   -0.0000
```

```
    0.0000   -0.0000   -0.0000         0    0.0000         0


C(:,:,14) =

   13.3583   11.7825  -12.4945   -0.0562    0.0466         0
  -14.0550    6.0182  -11.9902   -0.0394    0.0327         0
   12.6944    5.9258    0.0462    0.0394   -0.0327         0
   -0.0164    0.0394   -0.0394   -0.0000    0.0000         0
   -0.0374   -0.0154    0.0154   -0.0000    0.0000   -0.0000
         0         0         0         0    0.0000         0


C(:,:,15) =

   14.2588   11.7669  -14.0625   -0.0506    0.0440         0
  -14.2493    6.5240  -12.9905   -0.0485    0.0422         0
   14.3051    6.4090    0.0575    0.0485   -0.0422         0
   -0.0184    0.0485   -0.0485   -0.0000    0.0000         0
   -0.0412   -0.0201    0.0201   -0.0000    0.0000   -0.0000
    0.0000    0.0000   -0.0000         0         0         0


C(:,:,16) =

   14.9466   11.3750  -15.5967   -0.0434    0.0394         0
  -14.0486    6.9754  -13.8819   -0.0579    0.0526         0
   15.8830    6.8375    0.0689    0.0579   -0.0526         0
   -0.0192    0.0579   -0.0579    0.0000   -0.0000         0
   -0.0445   -0.0254    0.0254   -0.0000   -0.0000   -0.0000
    0.0000         0   -0.0000         0   -0.0000         0


C(:,:,17) =

   15.3791   10.5866  -17.0402   -0.0351    0.0330         0
  -13.4268    7.3618  -14.6438   -0.0675    0.0636         0
   17.3687    7.2022    0.0798    0.0675   -0.0636         0
   -0.0187    0.0675   -0.0675   -0.0000    0.0000         0
   -0.0473   -0.0311    0.0311   -0.0000    0.0000   -0.0000
   -0.0000    0.0000   -0.0000         0    0.0000         0


C(:,:,18) =

   15.5182    9.3978  -18.3294   -0.0261    0.0253         0
  -12.3739    7.6737  -15.2581   -0.0770    0.0748         0
   18.6955    7.4951    0.0893    0.0770   -0.0748         0
   -0.0165    0.0770   -0.0770   -0.0000         0         0
   -0.0494   -0.0369    0.0369   -0.0000    0.0000   -0.0000
   -0.0000   -0.0000    0.0000         0   -0.0000         0


C(:,:,19) =

   15.3346    7.8241  -19.3986   -0.0169    0.0168         0
  -10.9000    7.9030  -15.7093   -0.0863    0.0856         0
   19.7943    7.7096    0.0967    0.0863   -0.0856         0
   -0.0125    0.0863   -0.0863   -0.0000         0         0
   -0.0509   -0.0426    0.0426   -0.0000   -0.0000   -0.0000
    0.0000    0.0000   -0.0000         0         0         0


C(:,:,20) =
```

```
   14.8124    5.9031  -20.1858   -0.0081    0.0081         0
   -9.0383    8.0438  -15.9860   -0.0950    0.0956         0
   20.6004    7.8408    0.1015    0.0950   -0.0956         0
   -0.0070    0.0950   -0.0950   -0.0000    0.0000         0
   -0.0518   -0.0477    0.0477   -0.0000    0.0000   -0.0000
    0.0000    0.0000    0.0000         0    0.0000         0


C(:,:,21) =

   13.9540    3.6961  -20.6394   -0.0000   -0.0000         0
   -6.8474    8.0920  -16.0810   -0.1031    0.1041         0
   21.0606    7.8859    0.1031    0.1031   -0.1041         0
    0.0000    0.1031   -0.1031   -0.0000         0         0
   -0.0521   -0.0521    0.0521   -0.0000   -0.0000   -0.0000
   -0.0000         0         0    0.0000         0         0


C(:,:,22) =

   12.7831    1.2873  -20.7247    0.0070   -0.0070         0
   -4.4106    8.0466  -15.9917   -0.1101    0.1108         0
   21.1394    7.8436    0.1015    0.1101   -0.1108         0
    0.0081    0.1101   -0.1101   -0.0000   -0.0000         0
   -0.0518   -0.0553    0.0553   -0.0000    0.0000   -0.0000
   -0.0000   -0.0000    0.0000         0   -0.0000         0


C(:,:,23) =

   11.3454   -1.2195  -20.4283    0.0125   -0.0125         0
   -1.8331    7.9085  -15.7203   -0.1157    0.1152         0
   20.8239    7.7150    0.0967    0.1157   -0.1152         0
    0.0169    0.1157   -0.1157   -0.0000   -0.0000         0
   -0.0511   -0.0573    0.0573   -0.0000    0.0000   -0.0000
         0    0.0000   -0.0000         0   -0.0000         0


C(:,:,24) =

    9.7070   -3.7068  -19.7602    0.0165   -0.0161         0
    0.7644    7.6817  -15.2740   -0.1195    0.1172         0
   20.1263    7.5030    0.0893    0.1195   -0.1172         0
    0.0261    0.1195   -0.1195    0.0000   -0.0000         0
   -0.0499   -0.0579    0.0579   -0.0000   -0.0000   -0.0000
   -0.0000   -0.0000         0         0   -0.0000         0


C(:,:,25) =

    7.9493   -6.0513  -18.7539    0.0187   -0.0180         0
    3.2539    7.3719  -14.6640   -0.1213    0.1168         0
   19.0825    7.2123    0.0798    0.1213   -0.1168         0
    0.0351    0.1213   -0.1213    0.0000         0         0
   -0.0484   -0.0572    0.0572   -0.0000    0.0000   -0.0000
         0    0.0000   -0.0000         0   -0.0000         0


C(:,:,26) =

    6.1625   -8.1338  -17.4621    0.0192   -0.0182         0
    5.5103    6.9872  -13.9056   -0.1206    0.1139         0
   17.7485    6.8494    0.0689    0.1206   -0.1139         0
```

```
    0.0434    0.1206   -0.1206    0.0000         0         0
   -0.0463   -0.0551    0.0551   -0.0000   -0.0000   -0.0000
    0.0000    0.0000         0         0         0         0


C(:,:,27) =

    4.4369   -9.8485  -15.9517    0.0184   -0.0170         0
    7.4217    6.5371  -13.0167   -0.1175    0.1089         0
   16.1942    6.4221    0.0575    0.1175   -0.1089         0
    0.0506    0.1175   -0.1175    0.0000         0         0
   -0.0439   -0.0520    0.0520   -0.0000   -0.0000   -0.0000
         0         0         0         0         0         0


C(:,:,28) =

    2.8550  -11.1122  -14.2964    0.0164   -0.0150         0
    8.8986    6.0321  -12.0180   -0.1120    0.1020         0
   14.4962    5.9397    0.0462    0.1120   -0.1020         0
    0.0562    0.1120   -0.1120   -0.0000   -0.0000         0
   -0.0410   -0.0480    0.0480   -0.0000   -0.0000   -0.0000
         0   -0.0000    0.0000         0   -0.0000         0


C(:,:,29) =

    1.4841  -11.8710  -12.5695    0.0138   -0.0124         0
    9.8812    5.4835  -10.9314   -0.1044    0.0936         0
   12.7300    5.4122    0.0357    0.1044   -0.0936         0
    0.0596    0.1044   -0.1044         0   -0.0000         0
   -0.0376   -0.0434    0.0434   -0.0000    0.0000   -0.0000
    0.0000    0.0000   -0.0000         0   -0.0000         0


C(:,:,30) =

    0.3710  -12.1041  -10.8383    0.0109   -0.0097         0
   10.3437    4.9031   -9.7799   -0.0950    0.0842         0
   10.9640    4.8505    0.0263    0.0950   -0.0842         0
    0.0608    0.0950   -0.0950   -0.0000   -0.0000         0
   -0.0340   -0.0384    0.0384   -0.0000    0.0000   -0.0000
         0         0         0         0   -0.0000         0


C(:,:,31) =

   -0.4605  -11.8252   -9.1587    0.0081   -0.0071         0
   10.2951    4.3028   -8.5871   -0.0844    0.0741         0
    9.2550    4.2657    0.0185    0.0844   -0.0741         0
    0.0596    0.0844   -0.0844   -0.0000    0.0000         0
   -0.0300   -0.0332    0.0332   -0.0000    0.0000   -0.0000
    0.0000    0.0000    0.0000         0   -0.0000         0


C(:,:,32) =

   -1.0100  -11.0802   -7.5733    0.0056   -0.0049         0
    9.7776    3.6944   -7.3765   -0.0730    0.0636         0
    7.6454    3.6698    0.0123    0.0730   -0.0636         0
    0.0560    0.0730   -0.0730   -0.0000    0.0000         0
   -0.0259   -0.0281    0.0281   -0.0000    0.0000   -0.0000
         0    0.0000   -0.0000         0    0.0000         0
```

C(:,:,33) =

-1.2984	-9.9433	-6.1111	0.0036	-0.0031	0
8.8616	3.0900	-6.1723	-0.0612	0.0531	0
6.1640	3.0747	0.0076	0.0612	-0.0531	0
0.0505	0.0612	-0.0612	0	-0.0000	0
-0.0217	-0.0231	0.0231	-0.0000	-0.0000	-0.0000
0	0	0	0	-0.0000	0

C(:,:,34) =

-1.3636	-8.5112	-4.7889	0.0021	-0.0018	0
7.6406	2.5016	-4.9989	-0.0496	0.0429	0
4.8268	2.4929	0.0044	0.0496	-0.0429	0
0.0433	0.0496	-0.0496	0.0000	-0.0000	0
-0.0176	-0.0184	0.0184	-0.0000	-0.0000	-0.0000
0.0000	0	-0.0000	0	-0.0000	0

C(:,:,35) =

-1.2561	-6.8961	-3.6146	0.0011	-0.0009	0
6.2235	1.9418	-3.8814	-0.0385	0.0332	0
3.6409	1.9373	0.0022	0.0385	-0.0332	0
0.0352	0.0385	-0.0385	-0.0000	0.0000	0
-0.0137	-0.0141	0.0141	-0.0000	-0.0000	-0.0000
0.0000	-0.0000	-0.0000	0	0.0000	0

C(:,:,36) =

-1.0327	-5.2190	-2.5910	0.0005	-0.0004	0
4.7276	1.4237	-2.8464	-0.0282	0.0243	0
2.6087	1.4217	0.0010	0.0282	-0.0243	0
0.0267	0.0282	-0.0282	-0.0000	0.0000	0
-0.0100	-0.0102	0.0102	-0.0000	0.0000	-0.0000
-0.0000	-0.0000	0	0	0.0000	0

C(:,:,37) =

-0.7516	-3.6029	-1.7207	0.0002	-0.0002	0
3.2719	0.9614	-1.9225	-0.0190	0.0164	0
1.7319	0.9607	0.0004	0.0190	-0.0164	0
0.0185	0.0190	-0.0190	0	0	0
-0.0068	-0.0068	0.0068	-0.0000	-0.0000	-0.0000
-0.0000	-0.0000	0.0000	0	0.0000	0

C(:,:,38) =

-0.4665	-2.1671	-1.0094	0.0000	-0.0000	0
1.9711	0.5703	-1.1405	-0.0113	0.0097	0
1.0158	0.5701	0.0001	0.0113	-0.0097	0
0.0111	0.0113	-0.0113	-0.0000	0.0000	0
-0.0040	-0.0040	0.0040	-0.0000	-0.0000	-0.0000
0.0000	0	-0.0000	0	0.0000	0

C(:,:,39) =

-0.2238	-1.0226	-0.4699	0.0000	-0.0000	0

```
    0.9309    0.2671   -0.5342   -0.0053    0.0045         0
    0.4728    0.2671    0.0000    0.0053   -0.0045         0
    0.0052    0.0053   -0.0053         0    0.0000         0
   -0.0019   -0.0019    0.0019   -0.0000    0.0000   -0.0000
    0.0000   -0.0000   -0.0000         0    0.0000         0


C(:,:,40) =

   -0.0594   -0.2700   -0.1234    0.0000   -0.0000         0
    0.2458    0.0703   -0.1406   -0.0014    0.0012         0
    0.1242    0.0703    0.0000    0.0014   -0.0012         0
    0.0014    0.0014   -0.0014         0         0         0
   -0.0005   -0.0005    0.0005   -0.0000   -0.0000   -0.0000
         0         0         0         0   -0.0000         0


C(:,:,41) =

     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
```

```
subplot(3,1,2);
plot(t, tau(:,1:6)); xlabel('Time (s)'); ylabel('Joint torque (Nm)')
legend(["Link 1","Link 2","Link 3","Link 4","Link 5","Link 6"]);
title("$\dot{q} \neq 0, \ddot{q} \approx 0$", 'Interpreter','latex');
```

в) Нулевые скоости и ускорения.

```
[qshape1, qshape2] = size(Q, 1, 2)
```

```
qshape1 = 41
qshape2 = 6
```

```
tau = robot.rne(Q, zeros(qshape1, qshape2), zeros(qshape1, qshape2))
```

```
tau = 41×6
   -0.0000  443.4085   68.6735         0         0         0
   -0.0000  443.4576   68.6348         0         0         0
    0.0000  443.7863   68.3758         0         0         0
   -0.0000  444.6337   67.7067   -0.0000         0         0
   -0.0000  446.1960   66.4680         0         0         0
   -0.0000  448.6266   64.5278   -0.0000         0         0
    0.0000  452.0373   61.7781         0         0         0
    0.0000  456.4983   58.1332         0         0         0
    0.0000  462.0387   53.5285   -0.0000         0         0
   -0.0000  468.6472   47.9206   -0.0000         0         0
      ⋮
```

Матрица инерций:

```
M = robot.inertia(Q)
```

```
M =
M(:,:,1) =

   48.6350    1.3677   -0.1527   -0.0990   -0.0000         0
    1.3677   37.8192   -7.0494    0.0000   -0.0500         0
   -0.1527   -7.0494   11.2996   -0.0000    0.0500         0
   -0.0990    0.0000         0    0.1900         0         0
   -0.0000   -0.0500    0.0500         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,2) =

   48.6405    1.3673   -0.1527   -0.0990    0.0000         0
    1.3673   37.8215   -7.0506    0.0000   -0.0500         0
   -0.1527   -7.0506   11.2996    0.0000    0.0500         0
   -0.0990    0.0000    0.0000    0.1900         0         0
    0.0000   -0.0500    0.0500         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,3) =

   48.6776    1.3644   -0.1526   -0.0992    0.0001         0
    1.3644   37.8374   -7.0585    0.0000   -0.0500         0
   -0.1526   -7.0585   11.2996    0.0000    0.0500         0
   -0.0992    0.0000    0.0000    0.1900         0         0
    0.0001   -0.0500    0.0500         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,4) =

   48.7733    1.3570   -0.1524   -0.0996    0.0002         0
    1.3570   37.8783   -7.0789    0.0000   -0.0500         0
   -0.1524   -7.0789   11.2996    0.0000    0.0500         0
   -0.0996    0.0000    0.0000    0.1900         0         0
    0.0002   -0.0500    0.0500         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,5) =

   48.9501    1.3434   -0.1520   -0.1003    0.0005         0
    1.3434   37.9539   -7.1168    0.0000   -0.0500         0
   -0.1520   -7.1168   11.2996    0.0000    0.0500         0
   -0.1003    0.0000    0.0000    0.1900         0         0
    0.0005   -0.0500    0.0500         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,6) =

   49.2263    1.3219   -0.1513   -0.1015    0.0009         0
    1.3219   38.0722   -7.1759    0.0000   -0.0500         0
   -0.1513   -7.1759   11.2997    0.0000    0.0500         0
   -0.1015    0.0000    0.0000    0.1900         0         0
    0.0009   -0.0500    0.0500         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,7) =

   49.6161    1.2916   -0.1502   -0.1030    0.0014         0
```

```
    1.2916   38.2394   -7.2596    0.0000   -0.0500         0
   -0.1502   -7.2596   11.2998    0.0000    0.0500         0
   -0.1030    0.0000    0.0000    0.1900         0         0
    0.0014   -0.0500    0.0500         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,8) =

   50.1299    1.2513   -0.1486   -0.1051    0.0021         0
    1.2513   38.4605   -7.3703    0.0000   -0.0499         0
   -0.1486   -7.3703   11.3002    0.0000    0.0499         0
   -0.1051    0.0000    0.0000    0.1900         0         0
    0.0021   -0.0499    0.0499         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,9) =

   50.7747    1.2005   -0.1463   -0.1076    0.0029         0
    1.2005   38.7389   -7.5098    0.0000   -0.0498         0
   -0.1463   -7.5098   11.3008    0.0000    0.0498         0
   -0.1076    0.0000    0.0000    0.1900         0         0
    0.0029   -0.0498    0.0498         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,10) =

   51.5541    1.1385   -0.1432   -0.1105    0.0038         0
    1.1385   39.0769   -7.6793    0.0000   -0.0496         0
   -0.1432   -7.6793   11.3017    0.0000    0.0496         0
   -0.1105    0.0000    0.0000    0.1900         0         0
    0.0038   -0.0496    0.0496         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,11) =

   52.4681    1.0650   -0.1390   -0.1137    0.0047         0
    1.0650   39.4755   -7.8794    0.0000   -0.0493         0
   -0.1390   -7.8794   11.3033    0.0000    0.0493         0
   -0.1137    0.0000    0.0000    0.1900         0         0
    0.0047   -0.0493    0.0493         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,12) =

   53.5135    0.9798   -0.1335   -0.1172    0.0056         0
    0.9798   39.9345   -8.1100    0.0000   -0.0489         0
   -0.1335   -8.1100   11.3055    0.0000    0.0489         0
   -0.1172    0.0000    0.0000    0.1900         0         0
    0.0056   -0.0489    0.0489         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,13) =

   54.6833    0.8831   -0.1264   -0.1208    0.0064         0
    0.8831   40.4527   -8.3706    0.0000   -0.0484         0
   -0.1264   -8.3706   11.3086    0.0000    0.0484         0
   -0.1208    0.0000    0.0000    0.1900         0         0
    0.0064   -0.0484    0.0484         0    0.1000         0
```

```
         0         0         0         0         0    0.0500


M(:,:,14) =

   55.9669    0.7750   -0.1174   -0.1245    0.0070         0
    0.7750   41.0274   -8.6600    0.0000   -0.0476         0
   -0.1174   -8.6600   11.3127    0.0000    0.0476         0
   -0.1245    0.0000    0.0000    0.1900         0         0
    0.0070   -0.0476    0.0476         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,15) =

   57.3494    0.6560   -0.1063   -0.1281    0.0073         0
    0.6560   41.6549   -8.9764    0.0000   -0.0466         0
   -0.1063   -8.9764   11.3179    0.0000    0.0466         0
   -0.1281    0.0000    0.0000    0.1900         0         0
    0.0073   -0.0466    0.0466         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,16) =

   58.8116    0.5271   -0.0931   -0.1314    0.0072         0
    0.5271   42.3304   -9.3173    0.0000   -0.0454         0
   -0.0931   -9.3173   11.3242    0.0000    0.0454         0
   -0.1314    0.0000    0.0000    0.1900         0         0
    0.0072   -0.0454    0.0454         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,17) =

   60.3302    0.3891   -0.0777   -0.1343    0.0068         0
    0.3891   43.0478   -9.6797    0.0000   -0.0439         0
   -0.0777   -9.6797   11.3316    0.0000    0.0439         0
   -0.1343    0.0000    0.0000    0.1900         0         0
    0.0068   -0.0439    0.0439         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,18) =

   61.8776    0.2436   -0.0603   -0.1367    0.0058         0
    0.2436   43.8002  -10.0602    0.0000   -0.0422         0
   -0.0603  -10.0602   11.3401    0.0000    0.0422         0
   -0.1367    0.0000    0.0000    0.1900         0         0
    0.0058   -0.0422    0.0422         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,19) =

   63.4230    0.0921   -0.0413   -0.1385    0.0043         0
    0.0921   44.5798  -10.4546    0.0000   -0.0401         0
   -0.0413  -10.4546   11.3494    0.0000    0.0401         0
   -0.1385    0.0000    0.0000    0.1900         0         0
    0.0043   -0.0401    0.0401         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,20) =
```

```
   64.9332   -0.0634   -0.0209   -0.1396    0.0024         0
   -0.0634   45.3779  -10.8586    0.0000   -0.0379         0
   -0.0209  -10.8586   11.3593    0.0000    0.0379         0
   -0.1396    0.0000    0.0000    0.1900         0         0
    0.0024   -0.0379    0.0379         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,21) =

   66.3743   -0.2207   -0.0000   -0.1400   -0.0000         0
   -0.2207   46.1855  -11.2675    0.0000   -0.0354         0
   -0.0000  -11.2675   11.3696    0.0000    0.0354         0
   -0.1400    0.0000    0.0000    0.1900         0         0
   -0.0000   -0.0354    0.0354         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,22) =

   67.7136   -0.3778    0.0209   -0.1396   -0.0028         0
   -0.3778   46.9932  -11.6765    0.0000   -0.0327         0
    0.0209  -11.6765   11.3799    0.0000    0.0327         0
   -0.1396    0.0000    0.0000    0.1900         0         0
   -0.0028   -0.0327    0.0327         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,23) =

   68.9220   -0.5323    0.0413   -0.1385   -0.0058         0
   -0.5323   47.7917  -12.0807    0.0000   -0.0298         0
    0.0413  -12.0807   11.3898    0.0000    0.0298         0
   -0.1385    0.0000    0.0000    0.1900         0         0
   -0.0058   -0.0298    0.0298         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,24) =

   69.9759   -0.6824    0.0603   -0.1367   -0.0091         0
   -0.6824   48.5719  -12.4755    0.0000   -0.0269         0
    0.0603  -12.4755   11.3991    0.0000    0.0269         0
   -0.1367    0.0000    0.0000    0.1900         0         0
   -0.0091   -0.0269    0.0269         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,25) =

   70.8594   -0.8260    0.0777   -0.1343   -0.0124         0
   -0.8260   49.3252  -12.8564    0.0000   -0.0239         0
    0.0777  -12.8564   11.4076    0.0000    0.0239         0
   -0.1343    0.0000    0.0000    0.1900         0         0
   -0.0124   -0.0239    0.0239         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,26) =

   71.5648   -0.9616    0.0931   -0.1314   -0.0157         0
   -0.9616   50.0438  -13.2194    0.0000   -0.0209         0
    0.0931  -13.2194   11.4150    0.0000    0.0209         0
```

```
   -0.1314    0.0000    0.0000    0.1900         0         0
   -0.0157   -0.0209    0.0209         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,27) =

   72.0939   -1.0879    0.1063   -0.1281   -0.0188         0
   -1.0879   50.7205  -13.5609    0.0000   -0.0181         0
    0.1063  -13.5609   11.4213    0.0000    0.0181         0
   -0.1281    0.0000    0.0000    0.1900         0         0
   -0.0188   -0.0181    0.0181         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,28) =

   72.4570   -1.2040    0.1174   -0.1245   -0.0218         0
   -1.2040   51.3494  -13.8780    0.0000   -0.0153         0
    0.1174  -13.8780   11.4265    0.0000    0.0153         0
   -0.1245    0.0000    0.0000    0.1900         0         0
   -0.0218   -0.0153    0.0153         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,29) =

   72.6720   -1.3091    0.1264   -0.1208   -0.0244         0
   -1.3091   51.9255  -14.1680    0.0000   -0.0127         0
    0.1264  -14.1680   11.4306    0.0000    0.0127         0
   -0.1208    0.0000    0.0000    0.1900         0         0
   -0.0244   -0.0127    0.0127         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,30) =

   72.7625   -1.4029    0.1335   -0.1172   -0.0268         0
   -1.4029   52.4450  -14.4294    0.0000   -0.0103         0
    0.1335  -14.4294   11.4337    0.0000    0.0103         0
   -0.1172    0.0000    0.0000    0.1900         0         0
   -0.0268   -0.0103    0.0103         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,31) =

   72.7556   -1.4852    0.1390   -0.1137   -0.0288         0
   -1.4852   52.9054  -14.6607    0.0000   -0.0081         0
    0.1390  -14.6607   11.4359    0.0000    0.0081         0
   -0.1137    0.0000    0.0000    0.1900         0         0
   -0.0288   -0.0081    0.0081         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,32) =

   72.6798   -1.5560    0.1432   -0.1105   -0.0305         0
   -1.5560   53.3053  -14.8614    0.0000   -0.0062         0
    0.1432  -14.8614   11.4375    0.0000    0.0062         0
   -0.1105    0.0000    0.0000    0.1900         0         0
   -0.0305   -0.0062    0.0062         0    0.1000         0
         0         0         0         0         0    0.0500
```

M(:,:,33) =

72.5623	-1.6155	0.1463	-0.1076	-0.0319	0
-1.6155	53.6445	-15.0315	0.0000	-0.0045	0
0.1463	-15.0315	11.4384	0.0000	0.0045	0
-0.1076	0.0000	0.0000	0.1900	0	0
-0.0319	-0.0045	0.0045	0	0.1000	0
0	0	0	0	0	0.0500

M(:,:,34) =

72.4276	-1.6643	0.1486	-0.1051	-0.0330	0
-1.6643	53.9239	-15.1714	0.0000	-0.0032	0
0.1486	-15.1714	11.4390	0.0000	0.0032	0
-0.1051	0.0000	0.0000	0.1900	0	0
-0.0330	-0.0032	0.0032	0	0.1000	0
0	0	0	0	0	0.0500

M(:,:,35) =

72.2954	-1.7028	0.1502	-0.1030	-0.0338	0
-1.7028	54.1457	-15.2825	0.0000	-0.0021	0
0.1502	-15.2825	11.4394	0.0000	0.0021	0
-0.1030	0.0000	0.0000	0.1900	0	0
-0.0338	-0.0021	0.0021	0	0.1000	0
0	0	0	0	0	0.0500

M(:,:,36) =

72.1802	-1.7318	0.1513	-0.1015	-0.0344	0
-1.7318	54.3136	-15.3666	0.0000	-0.0013	0
0.1513	-15.3666	11.4395	0.0000	0.0013	0
-0.1015	0.0000	0.0000	0.1900	0	0
-0.0344	-0.0013	0.0013	0	0.1000	0
0	0	0	0	0	0.0500

M(:,:,37) =

72.0907	-1.7523	0.1520	-0.1003	-0.0349	0
-1.7523	54.4323	-15.4260	0.0000	-0.0007	0
0.1520	-15.4260	11.4396	0.0000	0.0007	0
-0.1003	0.0000	0.0000	0.1900	0	0
-0.0349	-0.0007	0.0007	0	0.1000	0
0	0	0	0	0	0.0500

M(:,:,38) =

72.0300	-1.7654	0.1524	-0.0996	-0.0351	0
-1.7654	54.5083	-15.4639	0.0000	-0.0003	0
0.1524	-15.4639	11.4396	0.0000	0.0003	0
-0.0996	0.0000	0.0000	0.1900	0	0
-0.0351	-0.0003	0.0003	0	0.1000	0
0	0	0	0	0	0.0500

M(:,:,39) =

71.9960	-1.7724	0.1526	-0.0992	-0.0353	0

```
   -1.7724   54.5493  -15.4845    0.0000   -0.0001         0
    0.1526  -15.4845   11.4396    0.0000    0.0001         0
   -0.0992    0.0000    0.0000    0.1900         0         0
   -0.0353   -0.0001    0.0001         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,40) =

   71.9826   -1.7751    0.1527   -0.0990   -0.0353         0
   -1.7751   54.5652  -15.4924    0.0000   -0.0000         0
    0.1527  -15.4924   11.4396    0.0000    0.0000         0
   -0.0990    0.0000    0.0000    0.1900         0         0
   -0.0353   -0.0000    0.0000         0    0.1000         0
         0         0         0         0         0    0.0500


M(:,:,41) =

   71.9806   -1.7755    0.1527   -0.0990   -0.0354         0
   -1.7755   54.5676  -15.4936    0.0000    0.0000         0
    0.1527  -15.4936   11.4396    0.0000   -0.0000         0
   -0.0990    0.0000    0.0000    0.1900         0         0
   -0.0354    0.0000   -0.0000         0    0.1000         0
         0         0         0         0         0    0.0500
```

Вектор гравитационных сил:

```
G = robot.gravload(Q)
```

```
G = 41×6
   -0.0000  443.4085   68.6735         0         0         0
   -0.0000  443.4576   68.6348         0         0         0
    0.0000  443.7863   68.3758         0         0         0
   -0.0000  444.6337   67.7067   -0.0000         0         0
   -0.0000  446.1960   66.4680         0         0         0
   -0.0000  448.6266   64.5278   -0.0000         0         0
    0.0000  452.0373   61.7781         0         0         0
    0.0000  456.4983   58.1332         0         0         0
    0.0000  462.0387   53.5285   -0.0000         0         0
   -0.0000  468.6472   47.9206   -0.0000         0         0
     ⋮
```

Матрица Кориолисовых сил

```
C = robot.coriolis(Q, zeros(qshape1, qshape2))
```

```
C =
C(:,:,1) =

     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0


C(:,:,2) =

     0     0     0     0     0     0
```

```
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0

C(:,:,3) =

     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0

C(:,:,4) =

     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0

C(:,:,5) =

     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0

C(:,:,6) =

     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0

C(:,:,7) =

     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0

C(:,:,8) =

     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
```

```
     0     0     0     0     0     0


C(:,:,9) =

     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0


C(:,:,10) =

     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0


C(:,:,11) =

     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0


C(:,:,12) =

     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0


C(:,:,13) =

     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0


C(:,:,14) =

     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0


C(:,:,15) =
```

```
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
```

```
C(:,:,16) =

     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
```

```
C(:,:,17) =

     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
```

```
C(:,:,18) =

     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
```

```
C(:,:,19) =

     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
```

```
C(:,:,20) =

     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
```

```
C(:,:,21) =

     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
```

```
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0


C(:,:,22) =

     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0


C(:,:,23) =

     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0


C(:,:,24) =

     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0


C(:,:,25) =

     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0


C(:,:,26) =

     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0


C(:,:,27) =

     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
```

```
C(:,:,28) =

     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0


C(:,:,29) =

     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0


C(:,:,30) =

     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0


C(:,:,31) =

     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0


C(:,:,32) =

     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0


C(:,:,33) =

     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0


C(:,:,34) =

     0     0     0     0     0     0
```

```
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0


C(:,:,35) =

     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0


C(:,:,36) =

     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0


C(:,:,37) =

     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0


C(:,:,38) =

     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0


C(:,:,39) =

     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0


C(:,:,40) =

     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
```

```
     0     0     0     0     0     0
```

```
C(:,:,41) =

     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
     0     0     0     0     0     0
```

```
subplot(3,1,3);
plot(t, tau(:,1:6 )); xlabel('Time (s)'); ylabel('Joint torque (Nm)')
legend(["Link 1","Link 2","Link 3","Link 4","Link 5","Link 6"]);
title("$\dot{q} = 0, \ddot{q} = 0$", 'Interpreter','latex');
```