```
clc;
clear all;
```

Problem 2

```
syms q1 q2 q3 a b c;
syms dq1 dq2 dq3;
syms m1 mt g;
T01 = [\cos(q1) \quad 0
                         sin(q1) 0; ...
       sin(q1) 0
                         cos(q1) 0; ...
                -1
                                 a; ...
       0
                0
                         0
                                 1];
T12 = [1]
                0
                         0
                                 0; ...
                                 0; ...
                0
       0
                         1
                                 b+q2; ...
       0
                 -1
                         0
       0
                         0
                 0
                                 1];
T23 = [0]
                         0
                                 0; ...
                                 0; ...
       -1
                0
                         0
       0
                0
                         1
                                 c+q3; ...
       0
                         0
                                 1];
T02 = T01*T12;
T03 = T02*T23
P03 = T03(1:3,4)
jacob = [diff(P03(1:3),q1), diff(P03(1:3),q2), diff(P03(1:3),q3)]
K1 = 0;
P1 = m1*g*a;
Vmt = jacob * [dq1; dq2; dq3];
K2 = 0.5*mt*(Vmt.' * Vmt);
P2 = mt*g*P03(3);
K = K1+K2;
P = P1+P2;
L = K-P
syms Q1 Q2 Q3 Q1(t) Q2(t) Q3(t) ddq1 ddq2 ddq3
diffqldot = diff(L,dq1);
diffqldot = subs(diffqldot, [q1 q2 q3 dq1 dq2 dq3], [Q1 Q2 Q3
 diff(Q1(t),t) diff(Q2(t),t) diff(Q3(t),t)]);
diffqldot = diff(diffqldot, t);
```

```
\label{eq:diffqldot} \mbox{diffqldot, [Q1 Q2 Q3 diff(Q1(t),t) diff(Q2(t),t)}
 diff(Q3(t),t) diff(Q1(t),t,t) diff(Q2(t),t,t) diff(Q3(t),t,t)], [q1
 q2 q3 dq1 dq2 dq3 ddq1 ddq2 ddq3]);
diffq1 = diff(L,q1);
Tau1 = diffq1dot - diffq1
diffq2dot = diff(L,dq2);
diffq2dot = subs(diffq2dot, [q1 q2 q3 dq1 dq2 dq3], [Q1 Q2 Q3
diff(Q1(t),t) diff(Q2(t),t) diff(Q3(t),t)]);
diffq2dot = diff(diffq2dot, t);
diffq2dot = subs(diffq2dot, [Q1 Q2 Q3 diff(Q1(t),t) diff(Q2(t),t)
 diff(Q3(t),t) diff(Q1(t),t,t) diff(Q2(t),t,t) diff(Q3(t),t,t)], [q1
 q2 q3 dq1 dq2 dq3 ddq1 ddq2 ddq3]);
diffq2 = diff(L,q2);
F2 = diffq2dot - diffq2
diffq3dot = diff(L,dq3);
diffq3dot = subs(diffq3dot, [q1 q2 q3 dq1 dq2 dq3], [Q1 Q2 Q3
diff(Q1(t),t) diff(Q2(t),t) diff(Q3(t),t)]);
diffq3dot = diff(diffq3dot, t);
diffq3dot = subs(diffq3dot, [Q1 Q2 Q3 diff(Q1(t),t) diff(Q2(t),t)
diff(Q3(t),t) diff(Q1(t),t,t) diff(Q2(t),t,t) diff(Q3(t),t,t)], [q1
 q2 q3 dq1 dq2 dq3 ddq1 ddq2 ddq3]);
diffq3 = diff(L,q3);
F3= diffq3dot - diffq3
T03 =
[sin(q1), cos(q1), 0, sin(q1)*(b+q2)]
[\cos(q1), \sin(q1), 0, \cos(q1)*(b+q2)]
        0,
                0, -1,
                             a - c - q3
        0,
                 0, 0,
                                       1]
[
P03 =
 sin(q1)*(b + q2)
 cos(q1)*(b + q2)
       a - c - q3
jacob =
[\cos(q1)*(b+q2), \sin(q1), 0]
[-\sin(q1)*(b+q2), \cos(q1), 0]
                          0, -1]
                  0,
```

```
L =
(mt*((dq2*sin(q1) + dq1*cos(q1)*(b + q2))^2 + (dq2*cos(q1) -
dq1*sin(q1)*(b+q2))^2 + dq3^2)/2 + g*mt*(c-a+q3) - a*g*m1
Tau1 =
(mt*(2*dq2*cos(q1)*(dq2*sin(q1) + dq1*cos(q1)*(b + q2)) +
2*cos(q1)*(b+q2)*(-sin(q1)*(b+q2)*dq1^2+2*dq2*cos(q1)*dq1+
ddq2*sin(q1) + ddq1*cos(q1)*(b + q2)) - 2*dq2*sin(q1)*(dq2*cos(q1)
 -dq1*sin(q1)*(b+q2)) + 2*sin(q1)*(b+q2)*(cos(q1)*(b+q2)*dq1^2
 + 2*dq2*sin(q1)*dq1 - ddq2*cos(q1) + ddq1*sin(q1)*(b + q2)) -
 2*dq1*cos(q1)*(b + q2)*(dq2*cos(q1) - dq1*sin(q1)*(b + q2)) -
 2*dq1*sin(q1)*(b + q2)*(dq2*sin(q1) + dq1*cos(q1)*(b + q2))))/2
F2 =
-(mt*(2*dq1*cos(q1)*(dq2*sin(q1) + dq1*cos(q1)*(b + q2))
-2*dq1*sin(q1)*(dq2*cos(q1) - dq1*sin(q1)*(b + q2))))/2 -
(mt*(2*cos(q1)*(cos(q1)*(b + q2)*dq1^2 + 2*dq2*sin(q1)*dq1 -
ddq2*cos(q1) + ddq1*sin(q1)*(b + q2)) - 2*sin(q1)*(- sin(q1)*(b + q2))
+ q2)*dq1^2 + 2*dq2*cos(q1)*dq1 + ddq2*sin(q1) + ddq1*cos(q1)*(b)
 + q2)) - 2*dq1*cos(q1)*(dq2*sin(q1) + dq1*cos(q1)*(b + q2)) +
2*dq1*sin(q1)*(dq2*cos(q1) - dq1*sin(q1)*(b + q2))))/2
F3 =
ddq3*mt - g*mt
```

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