
```
clc;
clear all;
```

Problem 2

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syms q1 q2 q3 a b c;
syms dq1 dq2 dq3;
syms m1 mt g;

T01 = [cos(q1)  0      sin(q1) 0; ...
       sin(q1)  0      cos(q1) 0; ...
       0        -1     0      a; ...
       0         0     0      1];

T12 = [1      0      0      0; ...
       0      0      1      0; ...
       0      -1     0      b+q2; ...
       0      0      0      1];

T23 = [0      1      0      0; ...
       -1     0      0      0; ...
       0      0      1      c+q3; ...
       0      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

diffq1dot = diff(L,dq1);
diffq1dot = subs(diffq1dot, [q1 q2 q3 dq1 dq2 dq3], [Q1 Q2 Q3
    diff(Q1(t),t) diff(Q2(t),t) diff(Q3(t),t)]);
diffq1dot = diff(diffq1dot, t);
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diffq1dot = subs(diffq1dot, [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);

Taul = 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, 0, -1]

```

$L =$

$$(mt*((dq2*\sin(q1) + dq1*\cos(q1)*(b + q2))^2 + (dq2*\cos(q1) - dq1*\sin(q1)*(b + q2))^2 + dq3^2))/2 + g*mt*(c - a + q3) - a*g*m1$$

$Tau1 =$

$$(mt*(2*dq2*\cos(q1)*(dq2*\sin(q1) + dq1*\cos(q1)*(b + q2)) + 2*\cos(q1)*(b + q2)*(-\sin(q1)*(b + q2)*dq1^2 + 2*dq2*\cos(q1)*dq1 + ddq2*\sin(q1) + ddq1*\cos(q1)*(b + q2)) - 2*dq2*\sin(q1)*(dq2*\cos(q1) - dq1*\sin(q1)*(b + q2)) + 2*\sin(q1)*(b + q2)*(cos(q1)*(b + q2)*dq1^2 + 2*dq2*\sin(q1)*dq1 - ddq2*\cos(q1) + ddq1*\sin(q1)*(b + q2)) - 2*dq1*\cos(q1)*(b + q2)*(dq2*\cos(q1) - dq1*\sin(q1)*(b + q2)) - 2*dq1*\sin(q1)*(b + q2)*(dq2*\sin(q1) + dq1*\cos(q1)*(b + q2))))/2$$

$F2 =$

$$- (mt*(2*dq1*\cos(q1)*(dq2*\sin(q1) + dq1*\cos(q1)*(b + q2)) - 2*dq1*\sin(q1)*(dq2*\cos(q1) - dq1*\sin(q1)*(b + q2))))/2 - (mt*(2*\cos(q1)*(cos(q1)*(b + q2)*dq1^2 + 2*dq2*\sin(q1)*dq1 - ddq2*\cos(q1) + ddq1*\sin(q1)*(b + q2)) - 2*\sin(q1)*(-\sin(q1)*(b + q2)*dq1^2 + 2*dq2*\cos(q1)*dq1 + ddq2*\sin(q1) + ddq1*\cos(q1)*(b + q2)) - 2*dq1*\cos(q1)*(dq2*\sin(q1) + dq1*\cos(q1)*(b + q2)) + 2*dq1*\sin(q1)*(dq2*\cos(q1) - dq1*\sin(q1)*(b + q2))))/2$$

$F3 =$

$$ddq3*mt - g*mt$$

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