```
clear all

%% Paramter preparation
syms th1 dth1 ddth1 th2 dth2 ddth2 real
syms c1 l1 c2 l2 m1 I1 m2 I2 real
syms g tau1 tau2 real

q = [th1; th2];
dq = [dth1; dth2];
ddq = [ddth1; ddth2];

u = [tau1; tau2];
p = [c1; l1; c2; l2; m1; I1; m2; I2; g];

%% Unit Vectors
ihat = [1; 0; 0];
jhat = [0; 1; 0];
khat = [0; 0; 1];

ahat = sin(th1)*ihat - cos(th1)*jhat;
bhat = sin(th1+th2)*ihat - cos(th1+th2)*jhat;

%% Kinematics
Rc1 = [c1*sin(th1); -c1*cos(th1); 0];                                   % COM1 Position
Rc2 = [l1*sin(th1) + c2*sin(th1+th2); -l1*cos(th1)-c2*cos(th1+th2); 0];  % COM2 Position
R1 = l1*ahat;       % endpoint1 position
R2 = R1 + l2*bhat;  % endpoint2 position

ddt = @(r) jacobian(r, [q; dq])*[dq; ddq];

v1 = ddt(Rc1);
v2 = ddt(Rc2);  % COM velocities

%% Kinetic and Potential engergy
T1 = 1/2*m1*dot(v1, v1) + 1/2*I1*(dth1)^2;
T2 = 1/2*m2*dot(v2, v2) + 1/2*I2*(dth1+dth2)^2;
T = T1 + T2;                    % Total kinetic

V1 = m1*g*dot(Rc1, -(-jhat));
V2 = m2*g*dot(Rc2, -(-jhat));
V = V1 + V2;                    % Total potential

%% Generalized Force
Q = [tau1; tau2];

%% Lagrange equation
L = T - V;
```

```
48 g = ddt(jacobian(L,dq).') - jacobian(L,q).' - Q;
49
50 A = simplify(jacobian(g,ddq));
51 b = simplify(A*ddq - g);
52
53 gravity = simplify(jacobian(V,q)).';
54 coriolis = simplify(-b - gravity + Q);
55
56 z = [q; dq];
57 dz = [dq; ddq];
58
59 rA = [l1*sin(th1); -l1*cos(th1)];
60 rB = [l1*sin(th1) + l2*sin(th1+th2); -l1*cos(th1) - l2*cos(th1+th2)];
61 keypoints = [rA rB];
62
63 J_B = jacobian(rB, q);
64 J_B_dot = reshape(ddt(J_B(:)), size(J_B));
65 vB = J_B*dq;
66
67 %% Save files
68 matlabFunction(A, 'file', 'A_pend', 'var', {z p});
69 matlabFunction(b, 'file', 'b_pend', 'var', {z u p});
70 matlabFunction(keypoints, 'file','keypoints_pend', 'var',{z p});
71 matlabFunction(J_B, 'file', 'Jacobian_rB','var',{z p});
72 matlabFunction(vB, 'file', 'velocity_rB','var',{z p});
73 matlabFunction(gravity, 'file','grav_pend', 'var', {z p});
74 matlabFunction(coriolis, 'file','coriolis_pend', 'var', {z p});
75 matlabFunction(J_B_dot, 'file', 'Jdot_rB', 'var',{z p});
```