```matlab
% Curran Robertson
% Lagrangian Equations of Motion of a Cart, Pendulum, Pulley System
 with
% No Dissipative Forces.
% April 16, 2023

clear all; clc; close all

% Symbols
syms m1 m2 m3 r theta dtheta x dx g l ddtheta ddx

% Constants

% Lagrangian ( L = T - V )
L = (1/2)*m1*r^2*dtheta^2 + (1/2)*m1*(dx+r*cos(theta))^2 +
 (1/2)*m1*(r*cos(theta))^2 + (1/2)*m2*dx^2 + (1/2)*m3*dx^2 -
 m1*g*r*cos(theta) - m3*g*(l-x);
L = expand(L);
L = simplify(L);
disp('L = ')
pretty(L)

% Partial Derivatives
    % DOF 1 : theta
d1 = diff(L, dtheta) ;
d2 = diff(L, theta);
    % DOF 2 : x
d4 = diff(L, dx);
d5 = diff(L, x);

% Time Derivatives
    % DOF 1 : theta
syms dtheta(t)
d3 = diff(subs(d1, dtheta, dtheta(t)), t);
    % DOF 2 : x
syms dx(t) theta(t)
d4_update = dx(t)*m1 + dx(t)*m2 + dx(t)*m3 + m1*r*cos(theta(t));
d6 = diff(d4_update, t);

% Eqns of Motion
    % DOF 1 : theta
eqn1 = d3 - d2 == 0;
    % DOF 2 : x
eqn2 = d6 - d5 == 0;

% Solutions
    % DOF 1 : theta
ddtheta = solve(subs(eqn1, diff(dtheta(t), t), ddtheta), ddtheta);
disp('ddtheta = ')
pretty(ddtheta)
    % DOF 2 : x
ddx = solve(subs(eqn2, diff(dx(t), t), ddx), ddx);
```

```
disp('ddx = ')
pretty(ddx)
```

```
L =
  2        2        2            2     2
dx  m1   dx  m2   dx  m3   dtheta  m1 r
------ + ------ + ------ + ------------- - g l m3 + g m3 x
   2        2        2            2

         2           2
   + m1 r  cos(theta)  + dx m1 r cos(theta) - g m1 r cos(theta)

ddtheta =
  dx sin(theta) - g sin(theta) + 2 r cos(theta) sin(theta)
- --------------------------------------------------------
                             r

ddx =
                    d
m1 r sin(theta(t)) -- theta(t) + g m3
                   dt
-------------------------------------
             m1 + m2 + m3
```

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