Plane for the design of an optimal trajectory and a passive walking gait for a compass robot.

1. Design a cyclic reference trajectory by optimization (LAB3).
   - Define the polynomial function using the general formulation of polynomial function, by considering coefficients connected to an initial configuration, an intermediate configuration and a final configuration, a initial velocity and a final velocity for q_1^d and q_2^d.
   - Using the conditions of cyclicity determine the number of optimization parameters (five parameters may be…) . Let us consider for the impact of the leg 2 with the ground , the model

   $$A(q)_{4\times4}\left(\dot{q}^+ - \dot{q}^-\right) = J_2^* I_2$$

   $$J_2\dot{q}^+ = 0$$

   - Consider the reduced dynamic inverse model of the compass robot in single support:

   $$A(q)_{2\times2}\ddot{q} + h(q,\dot{q})_{2\times2}\dot{q} + G(q)_{2\times1} = D_\Gamma \Gamma$$

   The we assume the compass robot is full actuated $D_\Gamma = I_{2\times2}$. We can determine the ground reaction $\vec{R}$ using the following balance equation in the center of mass:

   $$M\vec{\gamma}_G = M\vec{g} + \vec{R}$$

   - Define the criterion $J = \frac{1}{Mgd}\int_0^T \Gamma^\top \Gamma\, dt$ (transport cost). We propose to evaluate this integral using the backward difference method by using a sampling period $T/50$.
   - The choice of the constraint: $d > 0.2\,m$, $R_y > 0$, $I_{2y} > 0$, $\left|\frac{R_x}{R_y}\right| < 0.7$, $\left|\frac{I_x}{I_y}\right| < 0.7$, $|\dot{q}_i| < 3rd/s\ (i = 1,2)$ and $|\Gamma_i| < 50\,N.m\ (i = 1,2)$.
   - Using the software *fmincon* to rechearch give the optimization parameters which minimize J.
   - Give the profiles of $q_i\ (i = 1,2)$, $\dot{q}_i\ (i = 1,2)$, R_x, R_y and $\Gamma_i\ (i = 1,2)$.

     The following numerical data will be considered:

     l=0.8m; *M*=2 kg; I=0.08 k.m^2; s=0.45m, $\theta = 0$.

     an example to call fmincon or fgoalattain:

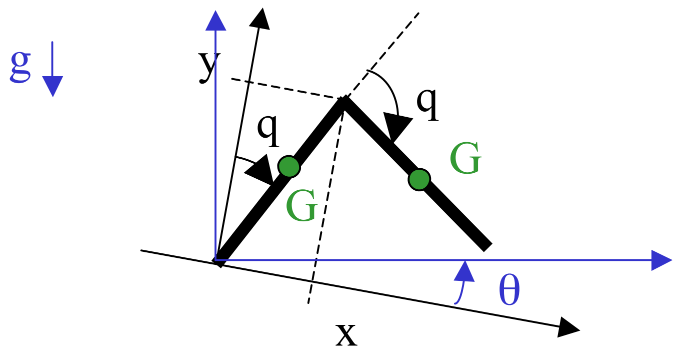
     1°) fmincon

```
Jsolcons0 = [ ?????]; %decision vars

% lower bound
lb = [ ?????];

% upper bound
ub = [ ??????];
```

```
% OPTIMIZATION: obj function -> 'resol', constraints ->
'mycon'
options =
optimset('Display','iter','MaxFunEvals',60000,'MaxIter',10000,
'LargeScale','off');
[Jsolcons,Fval,EXITFLAG] =
fmincon('resol',Jsolcons0,[],[],[],[],lb,ub,'mycon',options);
```

2°) Fgoalattain

```
   options_imp = optimset(options_imp,'TolFun',1e-
12,'TolX',1e-12);
[Jsolcons,Fval,EXITFLAG] =
fgoalatain('pbloptimpact',Jsol0cons,goal,weight,Aineq,Bineq,Ae
q,Beq,Ulb,Uub,'contraint',options_imp);
```



For each leg :
l : length
m : mass
I : inertia
s : distance between G
and the hip

1.1. Model in SS (with or without implicit contact constraint)
1.2. Model of impact

Remark: Precise clearly the set of state variable that will be used