<u>Homework 5:</u> Unconstrained n-D problems using computer software – Part 1
DUE DATE: 11/1/18

The objective of this homework is to solve an unconstrained optimization problems using different algorithms implemented via computer code:

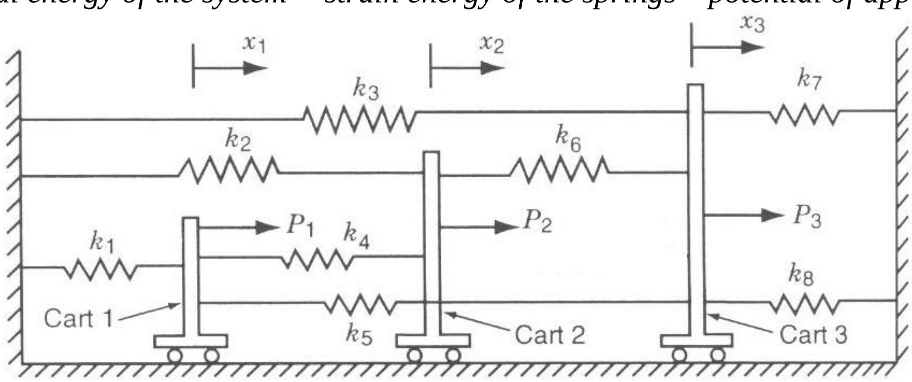
<u>Problem definition:</u>

Three carts, interconnected by springs, are subjected to the loads P_1, P_2, and P_3 as shown. The displacements of the carts can be found by minimizing the potential energy of the system. When there is no force applied to the bodies, the springs are at their natural position.

- The strain energy in a spring (with stiffness *k)* and end displacements (x_1 and x_2) is given by $(1/2)*k*(x_2-x_1)^2$.
- The potential of the applied force, F_i, is given by x_iF_i.

Derive the objective function $f(x_1, x_2, x_3)$ given the following data: k_1 = 5000 N/m, k_2 = 1500 N/m, k_3 = 2000 N/m, k_4 = 1000 N/m, k_5 = 2500 N/m, k_6 = 500 N/m, k_7 = 3000 N/m, k_8 = 3500 N/m, P_1 = 1000 N, P_2 = 2000 N, P_3 = 3000 N. Start at an initial point of [0; 0; 0].

Hint: *Potential energy of the system = strain energy of the springs – potential of applied loads*



<u>Homework approach:</u>

You will be solving this problem six ways. As part of this assignment, you will use:

- The Excel Solver
- The Matlab Optimization toolbox using the function *fminunc*
- A Fletcher-Reeves code created by you (this includes the Fletcher-Reeves code, a 1-D search, and the bounding phase algorithm) that uses the analytical derivative of the objective function when calculating the gradient.
- A Fletcher-Reeves code created by you that uses a central difference approximation with a fixed step size of 0.02 in all approximations.
- A BFGS code created by you that uses the analytical derivative of the objective function when calculating the gradient.
- A BFGS code created by you that uses a central difference approximation with a fixed step size of 0.02 in all approximations.

What you need to report:

For this assignment, you are to report:

- The final design solution and objective function value obtained when using the Excel Solver and the Matlab Optimization toolbox
- For the codes created by you:
    - The convergence criteria used for terminating the code(s)
    - The final design solution and objective function values obtained
    - A plot showing the value of the objective function as a function of the number of objective function evaluations.
        - Note - When you are using the analytical derivative you should only count the number of times you call the objective function. You do not need to count the number of times you call the gradient.
- Include a brief 3-4 sentence discussion comparing the performance of F-R and BFGS against each other, and discuss the impact of having to approximate the derivative.