Homework 6: Unconstrained n-D problems using computer software – Part 2
DUE DATE: 11/15/18

The objective of this homework is to solve an unconstrained optimization problems using Simulated Annealing.

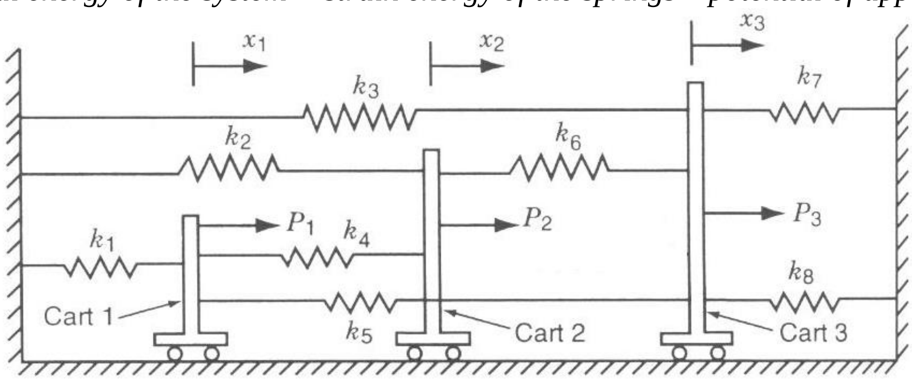
Problem definition:

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*



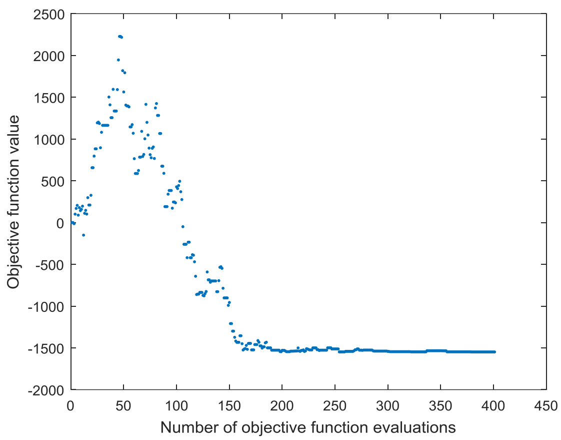
Homework approach:

You will be solving this problem using a code that you create that implements Simulated Annealing. As part of this assignment, you will:

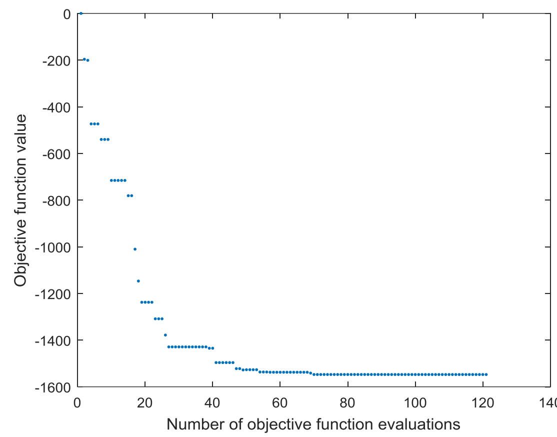
- Define what you are using as a "move limit box" around your current location when generating a new design. Also define your value of c for reducing the temperature when you transition based on your cooling schedule (n).
- Test how choices of initial temperature (T) and cooling schedule (n) influence quality of solution and the required number of function calls. You should choose two values of initial temperature (low and high, of your choosing) and use two different values for the cooling schedule (schedule 1, schedule2, of your choosing).
- Run (replicate) each scenario 5 times since SA is a stochastic approach. You will end up with 20 different runs, as shown in the table below.
- For each run record the optimum solution, the total number of objective function calls required, and the number of moves rejected per temperature.
- For a subset of your runs, plot the value of the objective function as a function of the number of objective function calls (plot the value of F at each iteration, even if the move

is rejected and your objective function does not change). As an example, I get the following plots when I set the temperature to be large (left figure) and small (right figure).

- Calculate the average optimum objective function value returned by your code (F_{avg}) across the five replications of an initial temperature and cooling schedule.
- Discuss how the choice of initial temperature and cooling schedule impact the quality of the optimum solution. Include a brief 3-4 sentence discussion comparing the performance of your SA algorithm to the F-R and BFGS solutions from the previous assignment.



High initial temperature



Low initial temperature

Run	Initial temperature	Cooling schedule	Replication	Optimum solution	Function calls	F_{avg}
1	Low	Schedule 1	1			
2	Low	Schedule 1	2			
3	Low	Schedule 1	3			
4	Low	Schedule 1	4			
5	Low	Schedule 1	5			
6	High	Schedule 1	1			
7	High	Schedule 1	2			
8	High	Schedule 1	3			
9	High	Schedule 1	4			
10	High	Schedule 1	5			
11	Low	Schedule 2	1			
12	Low	Schedule 2	2			
13	Low	Schedule 2	3			
14	Low	Schedule 2	4			
15	Low	Schedule 2	5			
16	High	Schedule 2	1			
17	High	Schedule 2	2			
18	High	Schedule 2	3			
19	High	Schedule 2	4			
20	High	Schedule 2	5			