ME 260: Structural Optimization: Size, Shape, and Topology		
Assigned: Sep. 7, 2021	Programming Assignment 1	Due: Sep. 21, 2021

You are asked to design a planar optimal truss by maximizing the stiffness for given amount of material. Please follow the steps below to do topology, shape, and size optimization. Specifications will be your own. Do take realistic values for material properties (with a specific material in mind), dimensions (with an application in mind like a bridge, building, or a tower), and boundary conditions (loads as well as where you fix).

Note: The Matlab codes are available either on the course website or course One Drive.

Question 1 (10 points)

a) Use YinSyn program (which runs in Matlab on Windows) to get an optimal topology. Note that it is a continuum-based approach.
b) Use also the fmincon program and optimality criteria program in Matlab to obtain the optimal topology.
c) By observing the solutions obtained with the three, finalize a topology for your truss.

Question 2 (5 points)

a) Is your truss statically determinate?
b) How many states of self-stress and degrees of freedom does it have?
   Check using **H** (static equilibrium) and **C** (compatibility) matrices. If they do have non-zero states of self-stress and degrees of freedom, visualize them and understand what they mean.

Question 3 (10 points)

a) Draw the force diagram for the truss you finalized in Question 1. Draw the form and force diagram side by side to compare them.
b) Compute the volume using $V = \frac{1}{S_y}\sum_{i=1}^{N} l_i p_i$ by assuming fully-stressed and uniformly stressed members (S_y is the yield strength of the material, and l_i and p_i are length and internal axial load of the truss member i).

Question 4 (25)

Optimize the shape of the truss to minimize $V = \frac{1}{S_y}\sum_{i=1}^{N} l_i p_i$. All vertices should lie within the design domain you had assumed in Question 1 when you change the shape. In this step, you are not allowed to change the topology.

Question 5 (10)

a) Take the changed shape of the truss that you got in Question 4, and do size optimization by changing the areas of cross section to maximize stiffness for given volume.
b) If your truss is not statically determinate, make it so by strategically removing some members. For the statically determinate topology that you have finalized in Question 5a, use the dual method code and obtain the optimal areas of cross-section.

Question 6 (10)

a) Compare the trusses you got in Questions 1, 4, 5a and 5b in terms of stiffness, maximum stress, maximum internal axial load, the net displacement of the vertex that moves the most, and the volume. Did your process of coming down from topology, shape, and size optimization of a truss improve the performance of the truss?
b) Based on all this experience, would you want to make any changes to your truss designs to improve it further? Whether you do it or not, give your preferred optimized truss as your final result.

Question 7 (10)

a) Does any member of your truss buckle?
b) If you are now allowed to change material, which material would you choose and why?
c) Compute the design index and choose the best material for your truss.

Anything you do extra will carry bonus points.