AE4132 - Finite Element Analysis

Spring 2021

Homework 4: 1D Bar Elements in 2D Space

Due Monday, March 29^{th} 2021

Problem 1

1. Write a finite element program in Phython to solve for 2-dimensional trusses. You can use 1D elements as discussed in class. The program should be able to read an input file with the following format:

   ```
   nnodes
   x_1 y_1 rx_1 ry_1 fx_1 fy_1
   x_2 y_2 rx_2 ry_2 fx_2 fy_2
   .
   .
   .
   x_nnodes y_nnodes rx_nnodes ry_nnodes fx_nnodes fy_nnodes
   nels
   n1_1 n2_1 E_1 A_1
   n1_2 n2_2 E_2 A_2
   .
   .
   .
   n1_nels n2_nels E_nels A_nels
   ```

   Where `nnodes` denotes the total number of nodes in the structure, `(x_i, y_i)` the coordinates of node `i`, `(rx_i, ry_i)` the constraints in the x and y directions for node `i` (1 means constrained, 0 free to move), and `(fx_i, fy_i)` the x and y component of the force applied at node `i`. Also, `nels` represents the number of elements in the structure, `(n1_i, n2_i)` the first and second node of element `i`, and `E_i` and A_i the corresponding Young's modulus and cross-sectional area. Note that the length of each element has to be computed based on its connectivity. That is, for a given element, you can get `n1` and `n2`, and with them the coordinates of the corresponding nodes.

2. Test your program on a simple structure you can check by hand, e.g., a simply supported triangle composed of three bars like the one discussed in class.

3. Once the program is written and tested, write the input files for the structures shown in Figure 1 and solve for all nodal displacements. All bars have identical cross-sectional area $A = 0.1\text{cm}^2$ and Young's modulus $E = 70$ GPa.

4. Plot the deformed structure for each case, coloring the bars according to the stress they are subject to. Magnify displacements if needed to facilitate visualization.

5. Compute the reaction forces.

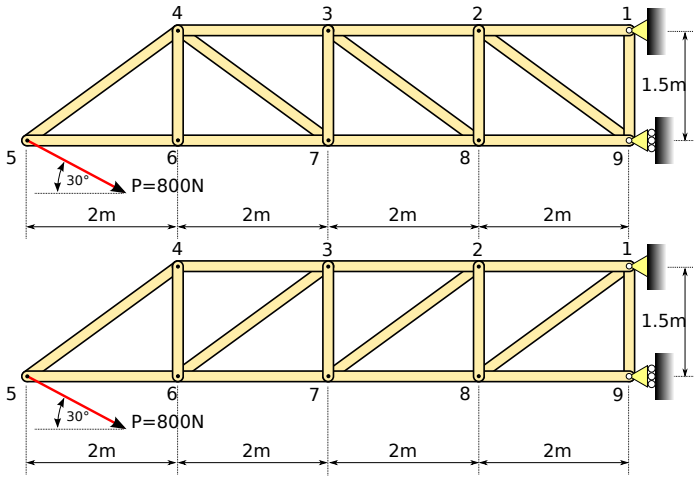

Figure 1: Structures for problem 1.