Name\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Student number\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Assignment 3**

The bar structure shown is loaded by two point forces of equal magnitude *P* but opposite directions. Determine the nodal displacements  and . Cross-sectional area *A* and Young’s modulus *E* are constants. Use two bar elements as indicated in the figure.

*L*

3

1

*Z*

*X*

2

*L*

1

2

*P*

*P*

**Solution template**

The generic force-displacement relationship of a bar element

****

depends on the cross-sectional area , Young’s modulus ,bar length, and force per unit length of the bar  in the direction of the axis.

Let us start with the free body diagram of the structure consisting of two bar elements (the structure is rotated clockwise just to save space).





























1

2

Element contributions (notice that  and the force components of the material and structural systems coincide here) are:

bar 1 : **** ****

bar 2 : **** ****

Equilibrium equations of the nodes are:

node 1: ** **

node 2: ** **

node 3: ** **

The outcome is 7 linear equations for the 2 displacements, 4 internal forces, and 1 constraint force. As the first step toward the solution (always), the internal forces are replaced in eq.5 and eq.6 (non-constrained nodes 1 and 2) by their expression given by eq.2, eq.3 and eq.4, to get the equilibrium equations of the nodes in terms of displacements:

node 1: ****

node 2: ****

After that, the unknown displacements follow from the system of linear equations for node 1 and 2. In matrix form (for example)

**  **.  **🡸**

Use the code of MEC-E1050 to check your solution!