# Assignment 6

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## Part a

In this part one should have write the code for the reduced Timoshenko. However the Timoshenko code is already provided, therefore the only change made to this code is the following stiffness matrix:

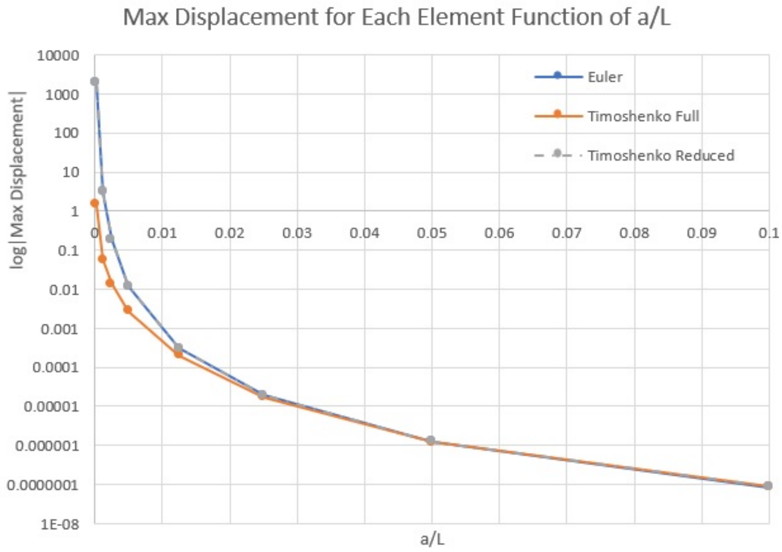
```
K_s = [   1   ,   len/2 ,   -1   ,   len/2 ;
        len/2 , len^2/4 , -len/2 , len^2/4 ;
         -1   ,  -len/2 ,    1   ,  -len/2 ;
        len/2 , len^2/4 , -len/2 ,  len^2/4 ];
```

## Part b

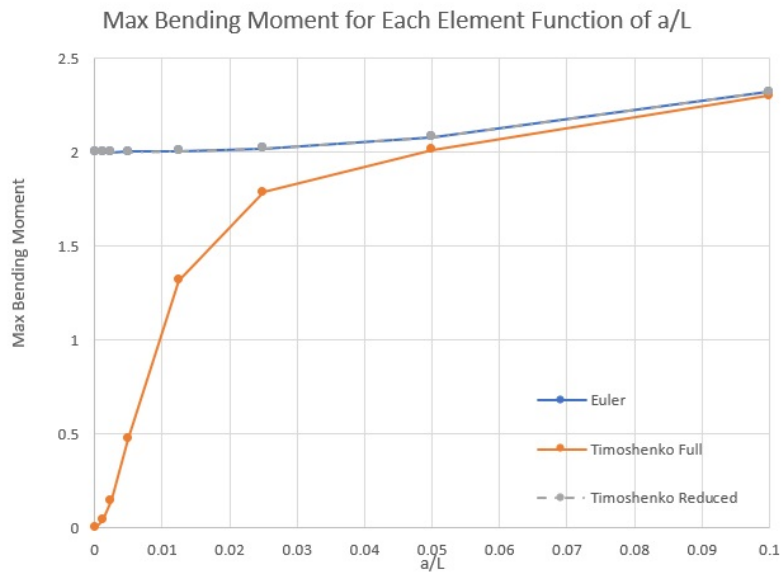
In this part the two provided codes (Euler and Timoshenko) and the fixed code for the reduced Timoshenko are used. A range of the side $a$ is given to compute the max displacement, moment and shear for each element type and compare the values.
GiD was used to make a beam with 64 structured bar elements. This beam is 4m long and simply supported on its edges (X-Constraint), with a downwoard uniform load of 1N/m along the element. In addition, the material's properties are the Young's Modulus $E = 21000MPa$ and the poisson's ratio $\nu = 0.25$.

| Element Type | a (m) | 0.001 | 0.005 | 0.01 | 0.02 | 0.05 | 0.1 | 0.2 | 0.4 |
|---|---|---|---|---|---|---|---|---|---|
| | a/L | 0.00025 | 0.00125 | 0.0025 | 0.005 | 0.0125 | 0.025 | 0.05 | 0.1 |
| Euler | Max Displacement | -1904.76 | -3.0477 | -0.1905 | -0.01191 | -0.00031 | -1.92381E-05 | -1.2381E-06 | -8.63095E-08 |
| | Max Moment | 1.99991 | 1.99996 | 2.00011 | 2.00071 | 2.00491 | 2.01991 | 2.07991 | 2.3199 |
| | Max Shear | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Timoshenko Full | Max Displacement | -1.46145 | -0.0574024 | -0.01358 | -0.0028 | -0.0002 | -1.70439E-05 | -1.20602E-06 | -8.76508E-08 |
| | Max Moment | 0.00153407 | 0.0376592 | 0.142589 | 0.469971 | 1.31771 | 1.78641 | 2.01344 | 2.30015 |
| | Max Shear | 1.96875 | 1.9688 | 1.96895 | 1.96954 | 1.97367 | 1.98844 | 2.0475 | 2.28375 |
| Timoshenko Reduced | Max Displacement | -1904.02 | -3.04652 | -0.19042 | -0.01191 | -0.00031 | -1.92594E-05 | -1.24504E-06 | -8.83472E-08 |
| | Max Moment | 1.99903 | 1.99907 | 1.99922 | 1.99982 | 2.00402 | 2.01901 | 2.07898 | 2.31887 |
| | Max Shear | 1.96875 | 1.9688 | 1.96895 | 1.96954 | 1.97367 | 1.98844 | 2.0475 | 2.28375 |

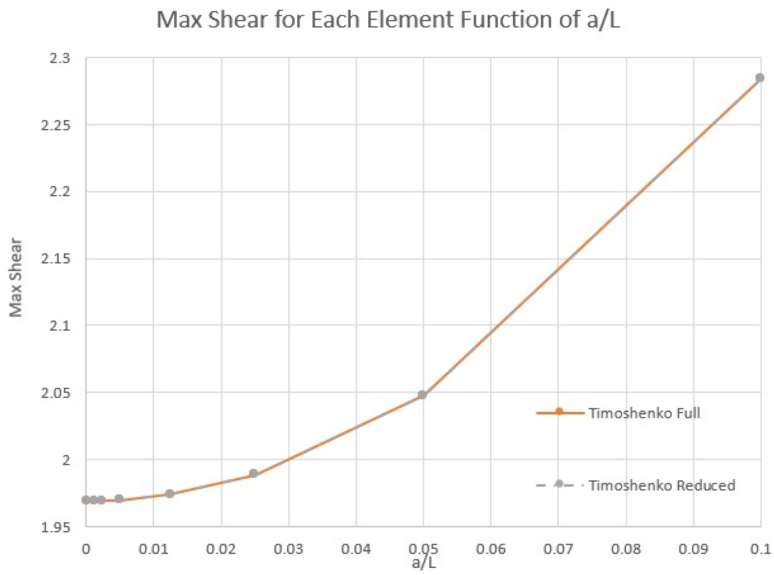
Table 1: Values for Different Thickness of the Beam Using Three Different Elements



Max Displacement for Each Element Function of a/L
log|Max Displacement|
a/L
Euler
Timoshenko Full
Timoshenko Reduced
10000
1000
100
10
1
0.1
0.01
0.001
0.0001
0.00001
0.000001
0.0000001
1E-08
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
0.1

Max Bending Moment for Each Element Function of a/L
Max Bending Moment
a/L
Euler
Timoshenko Full
Timoshenko Reduced
2.5
2
1.5
1
0.5
0
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
0.1




As shown in the values and graphs above, it is obvious that the values for reduced Timoshenko and Euler are similar, while the reduced Timoshenko has the advantage of calculating the shear stresses of the beam.

In addition, from the max displacement graph, it shows a large displacement for the first value of a/L for Euler and reduced and reduced Timoshenko, and a smaller value for Timoshenko. One can deduce that these values are a lot larger than the length L of the beam, so that the beam has already cracked.

Moreover, for small values of a/L, the Timoshenko element does not give accurate (or wrong) answers, because calculating the maximum moment for a beam is independent of the beam's thickness.Therefore, for all the cases the moment should be the same which is $2Nm$.

Finally, when a/L gets larger, the values seem to be "exploding", for example the shear has increased to 2.28, and the moment to 2.32. Therefore the answers for the displacements might not be accurate. The explanation behind it is that there might be some rounding errors while runing the code. One guess is that the value of the uniform force is too small compared to other values like Young's modulus.