National Taiwan University **Finite Element Method**

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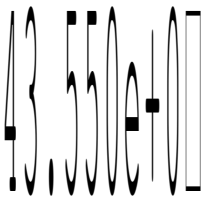


Lab Assignment 5, 05/02/2019, 1800 -- 2000

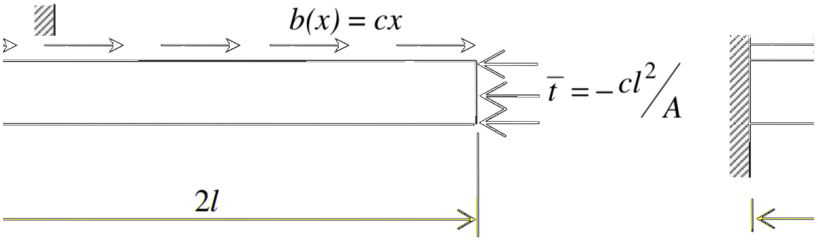
Due 2000

Lab Grading Policy: Attendance 20%, Score 100%

The Lab repeats the exercises you did in Midterm. You can use or modify your Midterm MATLAB codes and are encouraged to complete these exercises by 2000. You should upload them before 2100 on Saturday and no penalty will apply. **No late submission is permitted**. We will in general post the reference solutions by **Sunday**.

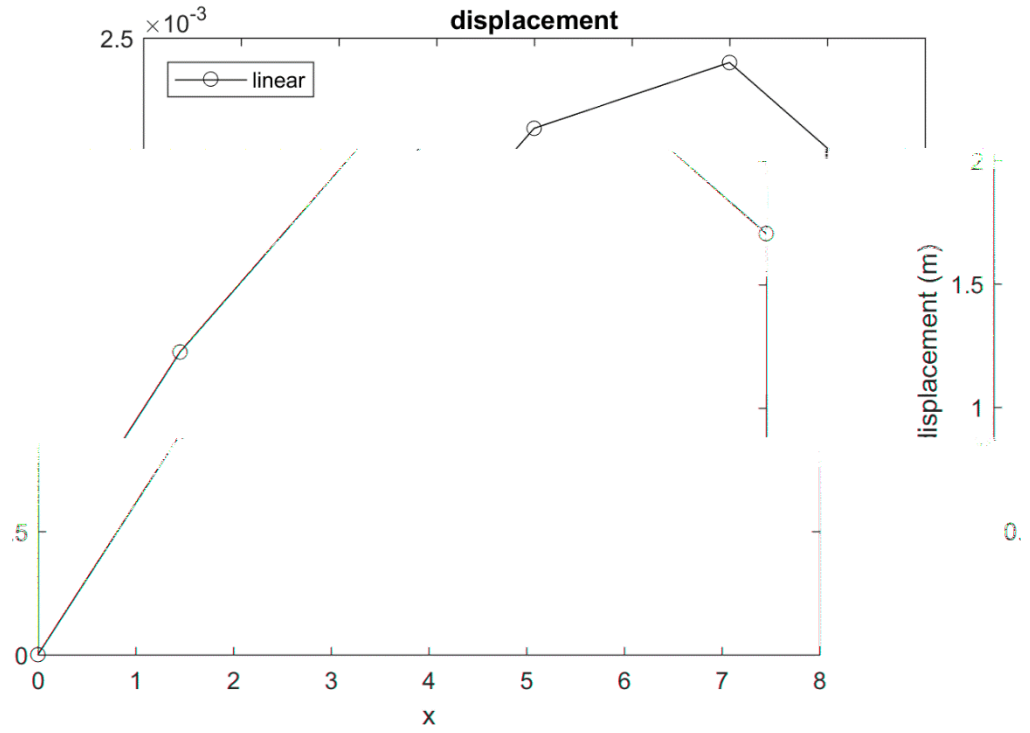
Download the `Lab5Dist.zip` **package from the ceiba course website. Once unzipping the file, you will find a folder** `r07XXXXXX`**, four empty sub-folders** `Prob1`, `Prob1`, `Prob3`, **and** `Prob4` **and a sub-folder** `Supplement`**. Change the folder name to your ID** `(r07XXXXXX to your ID)` **and write your solution directly in the sub-folder for each problem listed below. Consult and use any** `.m` **files in** `Supplement`

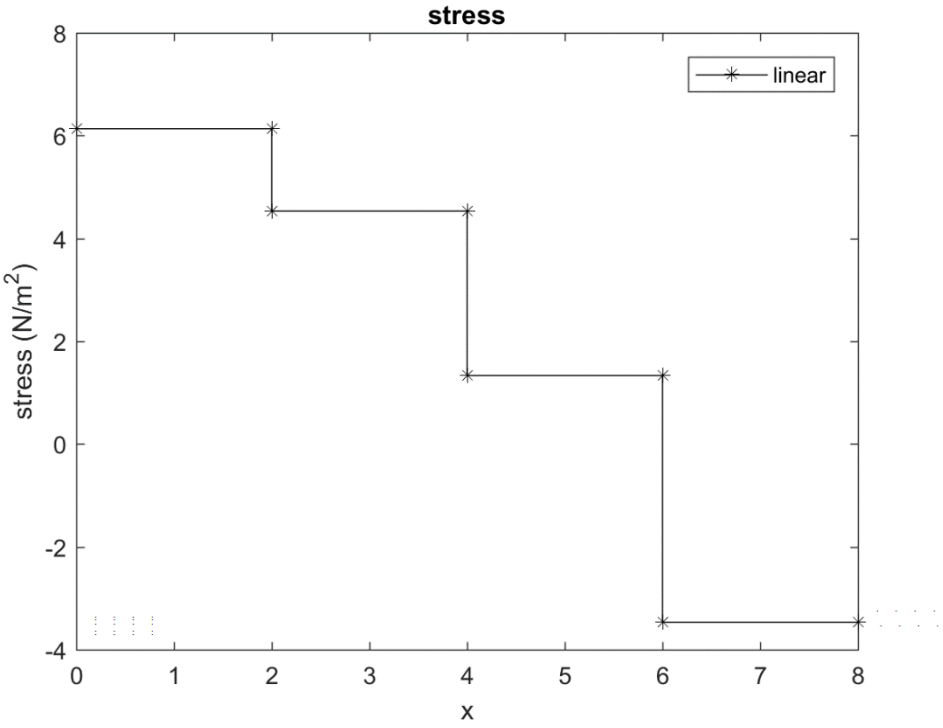
2. (20 %) Consider a bar under compression illustrated below



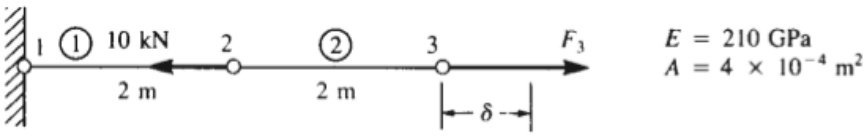
The material parameters considered are $E = 10^4\ \mathrm{N/m^2}$, $A = 5.0\ \mathrm{m^2}$, $c = 2.0\ \mathrm{N/m^2}$ and $l = 4$ m. Model the problem with 4 uniformly spacing linear elements. Report nodal displacements and reactions. Plot the distribution of displacements and stresses along the bar. Below are sample outputs and MATLAB plots.

```
Displacements
node      displacements
 1:         0.0000e+00
 2:         1.2267e-03
 3:         2.1333e-03
 4:         2.4000e-03
 5:         1.7067e-03
Reactions
node      reactions
 1:         -3.2000e+01
```





3. (30%) Consider a bar shown below with two linear element discretization. F_3 is the force large enough to induce the prescribed displacement. Prompt the user to enter the maximum allowable member force and report the maximum allowable prescribed displacement.



Below are two sample runs:

Run 1

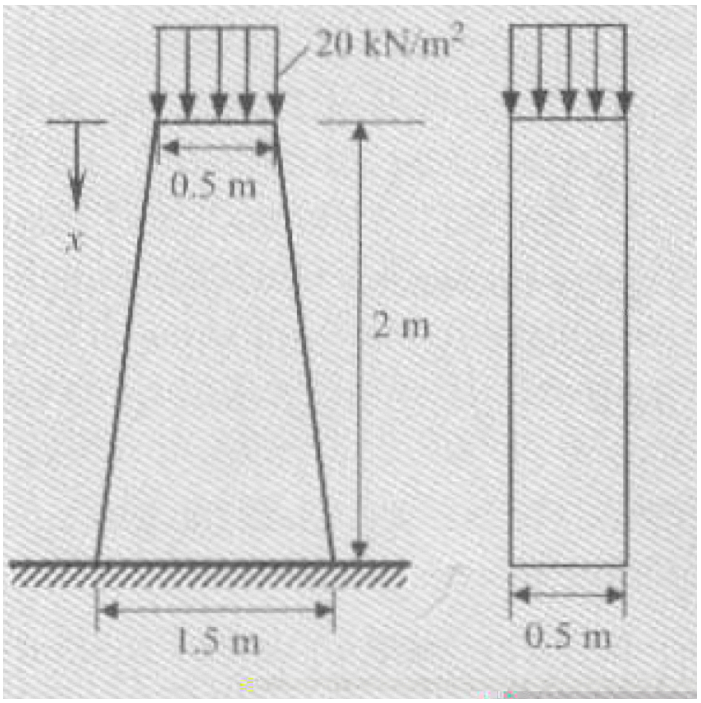
```
Enter the maximum allowable member force (unit: kN):500
The maximum allowable prescribed displacement is 2.3571e+01
(unit: mm)
```

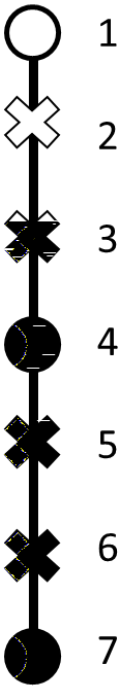
Run 2

```
Enter the maximum allowable member force (unit: kN):700
The maximum allowable prescribed displacement is 3.3095e+01
(unit: mm)
```

4. (30%) Consider the concrete pier problem shown below. The load $20\ \frac{\text{kN}}{\text{m}^2}$ represent the weight of bridge and a distribution of the traffic on the bridge. The concrete weighs $24\ \frac{\text{kN}}{\text{m}^3}$ and its modulus is $E = 2 \times 10^7\ \frac{\text{kN}}{\text{m}^2}$. Solve for the axial displacement and stress using 2 uniformly spacing cubic elements with a linearly varying area. Use three Gauss points for the problem. Below are the cubic shape functions in the parametric space $\xi \in [-1 \quad +1]$.

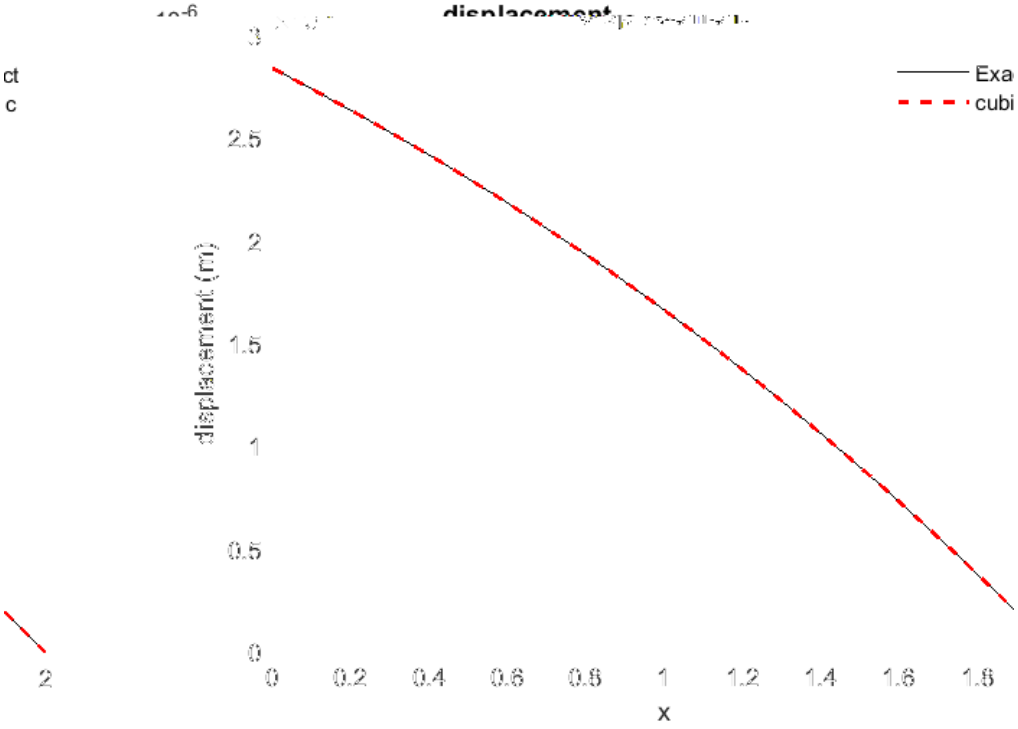
$$\mathbf{N}^{\text{L4}} = \left[-\frac{9}{16}\left(\xi+\frac{1}{3}\right)\left(\xi-\frac{1}{3}\right)(\xi-1)\ \ \frac{27}{16}(\xi+1)\left(\xi-\frac{1}{3}\right)(\xi-1)\right.$$
$$\left.-\frac{27}{16}(\xi+1)\left(\xi+\frac{1}{3}\right)(\xi-1)\ \ \frac{9}{16}(\xi+1)\left(\xi+\frac{1}{3}\right)\left(\xi-\frac{1}{3}\right)\right]$$

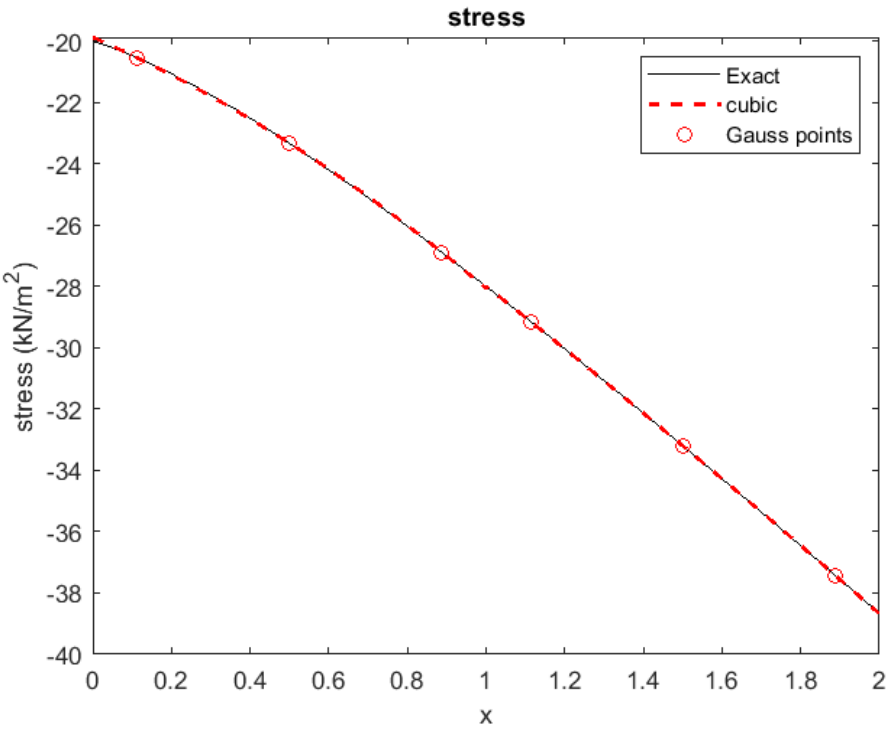




Below are sample outputs and MATLAB plots.

```
Displacements
node      displacements
 1:         2.8394e-06
 2:         2.4910e-06
 3:         2.1017e-06
 4:         1.6622e-06
 5:         1.1672e-06
 6:         6.1377e-07
 7:         0.0000e+00
Reactions
node      reactions
 7:         -2.9000e+01
```


displacement
Exa
cubi
displacement (m)
x
0
0.5
1
1.5
2
2.5
0.2
0.4
0.6
0.8
1.2
1.4
1.6
1.8


stress
Exact
cubic
Gauss points
stress (kN/m^2)
x
-20
-22
-24
-26
-28
-30
-32
-34
-36
-38
-40
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2