EN3: Introduction to Engineering and Statics

Analysis of deformation and failure in structures
Due 12:00 noon Thursday November 18, 2010.

Division of Engineering
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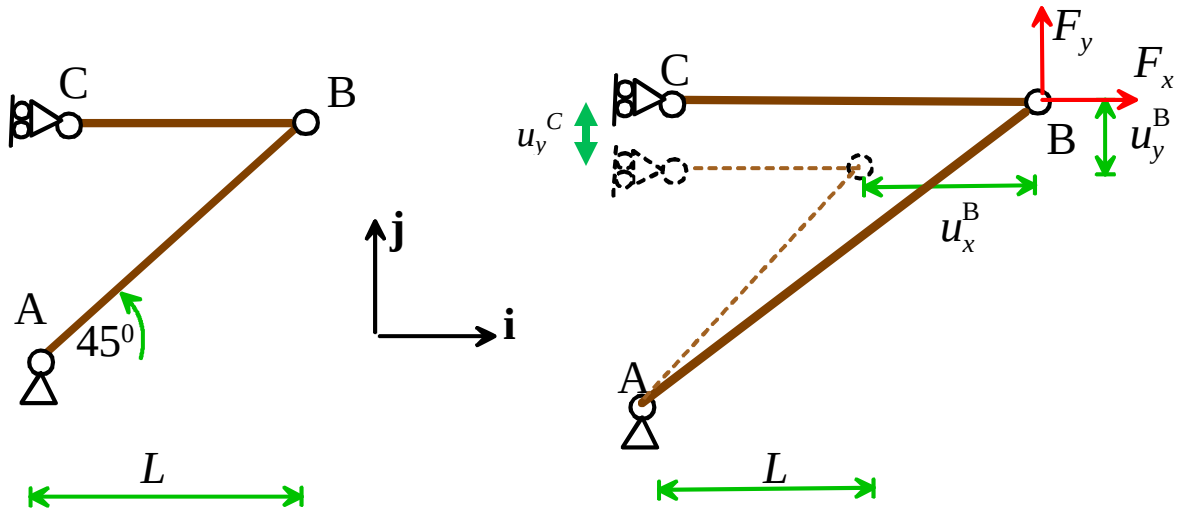
1. Work through the tutorial for the 2D and 3D structural analysis spreadsheet. No solution is required for this problem.

2. The figure shows a simple two member frame, before and after loads $F_x\boldsymbol{i}+F_y\boldsymbol{j}$ are applied to joint B. All three members have stiffness k.



2.1 Write down expressions for the undeformed lengths of members AB and BC, in terms of L.

2.2 Write down expressions for the deformed lengths of members AB and BC, in terms of L, u_x^B, u_y^B, and u_y^C.

2.3 Find a formula for the potential energy of deformation for the structure members, in terms of k, L, u_x^B, u_y^B, and u_y^C.

2.4 Find a formula for the potential energy of the force $F_x\boldsymbol{i}+F_y\boldsymbol{j}$.

2.5 Find a formula for the total potential energy of the structure.

2.6 Find formulas for the internal forces in members AB and BC of the structure in terms of k, L, u_x^B, u_y^B, and u_y^C.

2.7 Program an EXCEL spreadsheet that will calculate the values of u_x^B, u_y^B, and u_y^C by minimizing the potential energy of the structure. Add a section to the spreadsheet that will calculate the forces in the two members. Test your spreadsheet by calculating u_x^B, u_y^B, and u_y^C and the internal forces in the two members for $k=1000000$ N/m, $L=1m$, $Fx = 100N$, and $Fy = 0N$. Hand in a copy of your spreadsheet set up to show the results of this calculation.

2.8 Calculate formulas for the internal forces in members AB and BC in terms of F_x and F_y by hand, using the method of sections or joints. Calculate values for the internal forces for $Fx = 100N$, and $Fy = 0N$. Compare your answer against part 2.7.

2.9 Now use your spreadsheet to calculate internal forces in members AB and BC for $k=1000$ N/m, $L=1m$, $Fx = 100N$, and $Fy = 0N$. Explain why the formulas you found in part 2.8 do not predict correctly the internal forces for this case.

3. Solve problem 6.24 in Bedford and Fowler using the 2D EXCEL structural analysis spreadsheet. Check your answer for members BC, BI and BJ against your previous solution, found using the method of joints/sections.

4. The 3D truss shown in figure 6.62 of Bedford and Fowler supports a load of 200lb (and not an 800lb load) at joint A. It is made of PVC members, each with a 0.81" inner diameter and a 1.05" outer diameter.

4.1 Calculate the stiffness of each member. Note that the Young's Modulus for PVC is 2.4 GN/m^2. Express your answer in N/m.

4.2 Calculate the maximum internal force that each member can withstand without permanent deformation. Express your answer in Newtons.

4.3 Calculate the buckling load for each member of the structure. Express your answer in Newtons.

4.4 Use the 3D EXCEL structural analysis spreadsheet to calculate forces in all the members of the structure under the loading indicated. Hand in a copy of the member force table.

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4.5 Identify the member with the largest tensile internal force, and therefore the member that is closest to yield.

4.6 Identify the member that is closest to buckling (note that this is not necessarily the member with the biggest compressive force, because longer members have a lower resistance to buckling).

5. Solve problems 9.11 and 9.104 in Bedford and Fowler.