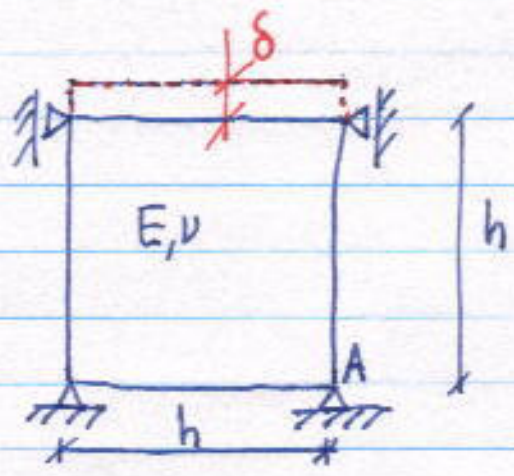


16.21  
Practice problems

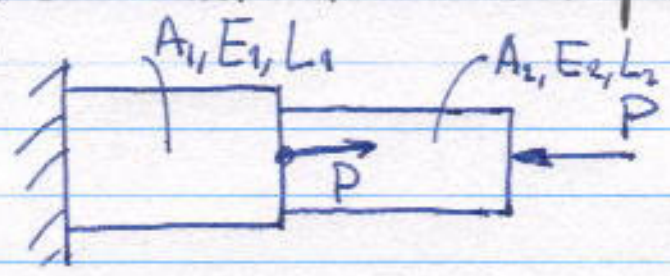
① Model the following (plane strain) structure with one 4-node quadrilateral element. Find the horizontal reaction at A when the displacement  $\delta$  is imposed. Compare with exact solution. (In the final the stiffness matrix for the element would be given. In this case obtain it or get it from the notes).



② Derive the PVD for the following differential equation associated with the buckling of beams

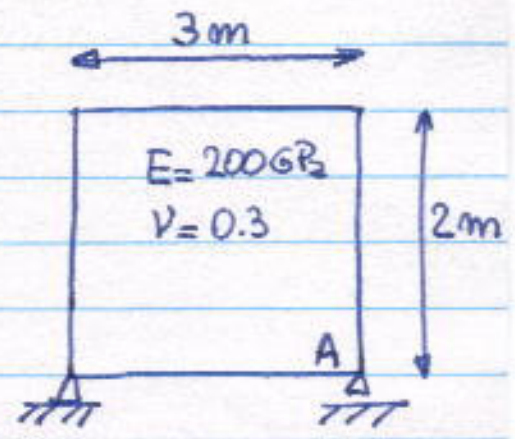
$$\frac{d^2}{dx^2} \left( EI \frac{d^2 w_0}{dx^2} \right) + N \frac{d^2 w_0}{dx^2} = 0 \quad 0 < x < L$$

③ Find stresses in each member of the following rod-like structure. Use finite elements. Compare with exact solution.



④ The 4-node plane strain element is subjected to the constant stresses:

$$\begin{aligned} \sigma_{11} &= 200 \text{ MPa} \\ \sigma_{22} &= 100 \text{ MPa} \\ \sigma_{12} &= 100 \text{ MPa} \end{aligned} \quad (\text{loads not shown})$$



Compute the horizontal displacement at A

⑤ Consider the structure in the figure

- Write down the PVD for this problem by specializing the general expression.
- Use the PVD to check whether:

$$\sigma(x) = \left( \frac{72}{73} + \frac{24x}{73L} \right) \frac{F}{A_0}$$

is the exact solution. Use the virtual displacement fields

$$\textcircled{1} \delta u = a x \quad \textcircled{2} \delta u = a x^3$$

