1. In Fig. 1, let cross-sectional area A vary linearly from $3A_0$ at $x = 0$ to A_0 $x = L$. Model the bar using discrete springs/elements. To determine the stiffness of the discrete springs/elements, consider the cross-sectional area of each element to be that of the actual bar corresponding to the location of element midpoint. Assume that elastic modulus E is constant. Do the following:

   (a) Determine the displacement at $x = L$ due to load P by considering two and four spring elements of equal length (manual calculations).

   (b) Compute the percentage error of your results by comparing the FE solution with the exact solution, which is equal to $\frac{PL}{2EA_0} ln(3)$.

   (c) Determine the displacement at the end by discretizing the bar into 2, 4, 6, 8 and 10 linear elements using the code (suitably modify the code already given to you).

   (d) Determine the displacement at the end by discretizing the bar into 2 and 4 quadratic elements using the code (suitably modify the code already given to you).

   (e) Plot displacement at the end versus no. of elements (both linear and quadratic elements).

   (f) Do you see any trends emerging from plots? What are your conclusions?

Assume $P = 100$, $A_0 = 10$, $L = 100$ and $E = 200000$ (all in appropriate units).

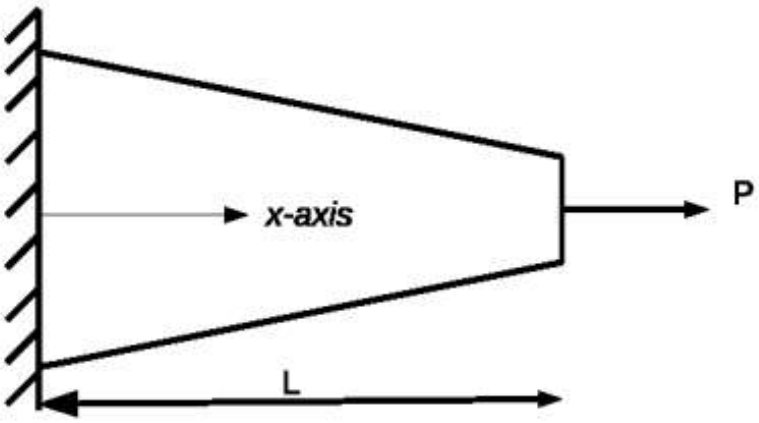

Figure 1: Schematic of a tapered bar subjected to load P at its end.