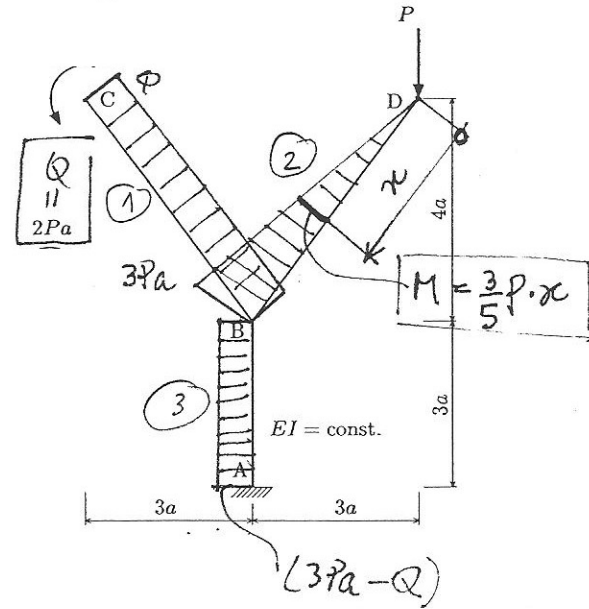


$$U(P, Q) = \sum_{b=1}^3 \int_0^{l_b} \frac{M^2}{2EI} dx = \frac{1}{2EI} \left( Q^2 \cdot 5a + \int_0^{5a} \left( \frac{3P}{5}x \right)^2 dx + (3Pa - Q)^2 \cdot 3a \right)$$

$$U(P, Q) = \frac{1}{2EI} \left[ 5Q^2 a + 15P^2 a^3 + (3Pa - Q)^2 \cdot 3a \right]$$

a) Para  $Q = 2Pa$

$$U(P) = \frac{19P^2 a^3}{EI}$$



b) Rotacion de Extremidade C =

$$\varphi_C = \frac{\partial U(Q, P)}{\partial Q} \Big|_{Q=2Pa} = \frac{1}{2EI} \left( 10Qa + 2 \cdot (3Pa - Q) \cdot (-1) \cdot 3a \right) \Big|_{Q=2Pa}$$

$$\varphi_C = \frac{7Pa^2}{EI} \quad (\curvearrowright)$$

Deslocamento vertical em D:

$$N_C = \frac{\partial U(Q, P)}{\partial P} \Big|_{Q=2Pa} = \frac{1}{2EI} \left( 30Pa^3 + 2 \cdot (3Pa - Q) \cdot 3a \cdot 3a \right) \Big|_{Q=2Pa}$$

$$N_C = \frac{24Pa^3}{EI} \quad (\downarrow)$$