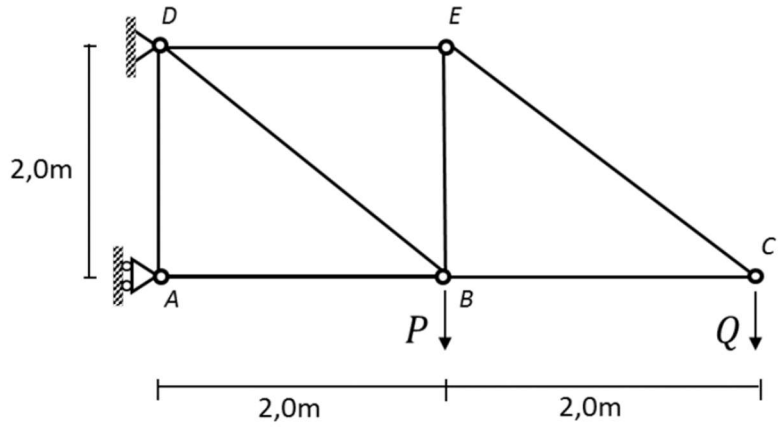
restart :

Sistema real



Reações de apoio

$solve(\{HA + HD = 0, VD - P - Q = 0, -HD \cdot 2 - P \cdot 2 - Q \cdot 4 = 0\}, \{HA, HD, VD\})$

$$\{HA = P + 2\,Q, HD = -P - 2\,Q, VD = P + Q\} \quad \textbf{(1)}$$

$assign(\%)$

Esforços nas barras (método dos nós)

$$EQ1 := HA + NAB = 0 :$$
$$EQ2 := NAD = 0 :$$
$$EQ3 := NBC - NAB - NBD \cdot \cos\left(\frac{\mathrm{Pi}}{4}\right) = 0 :$$
$$EQ4 := -P + NBE + NBD \cdot \cos\left(\frac{\mathrm{Pi}}{4}\right) = 0 :$$
$$EQ5 := -NBC - NCE \cdot \cos\left(\frac{\mathrm{Pi}}{4}\right) = 0 :$$
$$EQ6 := -Q + NCE \cdot \cos\left(\frac{\mathrm{Pi}}{4}\right) = 0 :$$
$$EQ7 := -NDE + NCE \cdot \cos\left(\frac{\mathrm{Pi}}{4}\right) = 0 :$$
$$EQ8 := -NBE - NCE \cdot \cos\left(\frac{\mathrm{Pi}}{4}\right) = 0 :$$
$$EQ9 := HD + NDE + NBD \cdot \cos\left(\frac{\mathrm{Pi}}{4}\right) = 0 :$$
$$EQ10 := VD - NAD - NBD \cdot \cos\left(\frac{\mathrm{Pi}}{4}\right) = 0 :$$

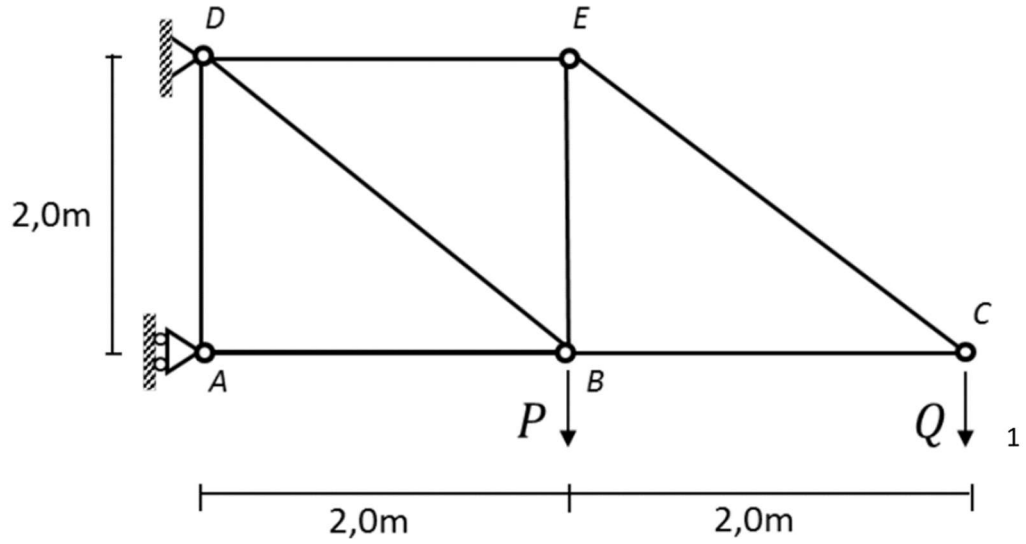
$solve(\{EQ1, EQ2, EQ3, EQ4, EQ5, EQ6, EQ7, EQ8, EQ9, EQ10\}, \{NAB, NBC, NCE, NDE, NBE, NBD, NAD\})$

$$\{NAB = -P - 2\,Q, NAD = 0, NBC = -Q, NBD = \sqrt{2}\ (P + Q), NBE = -Q, NCE = \sqrt{2}\ Q, NDE \quad \textbf{(2)}$$

$= Q\}$

$assign(\%)$

Sistema fictício



$NABf := subs([P = 0, Q = 1], NAB)$

-2 **(3)**

$NADf := subs([P = 0, Q = 1], NAD)$

0 **(4)**

$NBCf := subs([P = 0, Q = 1], NBC)$

-1 **(5)**

$NBDf := subs([P = 0, Q = 1], NBD)$

$\sqrt{2}$ **(6)**

$NBEf := subs([P = 0, Q = 1], NBE)$

-1 **(7)**

$NCEf := subs([P = 0, Q = 1], NCE)$

$\sqrt{2}$ **(8)**

$NDEf := subs([P = 0, Q = 1], NDE)$

1 **(9)**

Área das barras

$De := 0.05$:
$t := 0.005$:

$$Ab := \frac{\pi \cdot De^2}{4} - \frac{\pi \cdot (De - 2 \cdot t)}{4}$$

$-0.009375000000\,\pi$ **(10)**

Comprimento das barras

$LAB := 2 :$
$LBC := 2 :$
$LAD := 2 :$
$LDE := 2 :$
$LBE := 2 :$
$LBD := \sqrt{2^2 + 2^2} :$
$LCE := \sqrt{2^2 + 2^2} :$

Aplicando o princípio dos trabalhos virtuais para calcular o deslocamento vertical no Ponto C:

$$\delta C := \frac{1}{E \cdot A} \cdot (NAB \cdot NABf \cdot LAB + NBC \cdot NBCf \cdot LBC + NAD \cdot NADf \cdot LAD + NDE \cdot NDEf \cdot LDE + NBE \cdot NBEf \cdot LBE + NBD \cdot NBDf \cdot LBD + NCE \cdot NCEf \cdot LCE)$$

$$\frac{4\,P + 14\,Q + 4\,\sqrt{2}\,(P + Q) + 4\,\sqrt{2}\,Q}{E\,A} \quad \textbf{(11)}$$

$evalf(\delta C)$

$$\frac{9.656854248\,P + 25.31370850\,Q}{E\,A} \quad \textbf{(12)}$$

Substituindo o valor da área, obtém-se:

$evalf(expand(subs(A = Ab, \delta C)))$

$$-\frac{327.8796988\,P}{E} - \frac{859.4777249\,Q}{E} \quad \textbf{(13)}$$