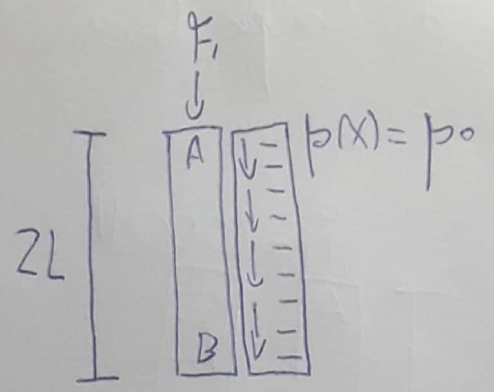
# Ex_Metsec_Axial_01

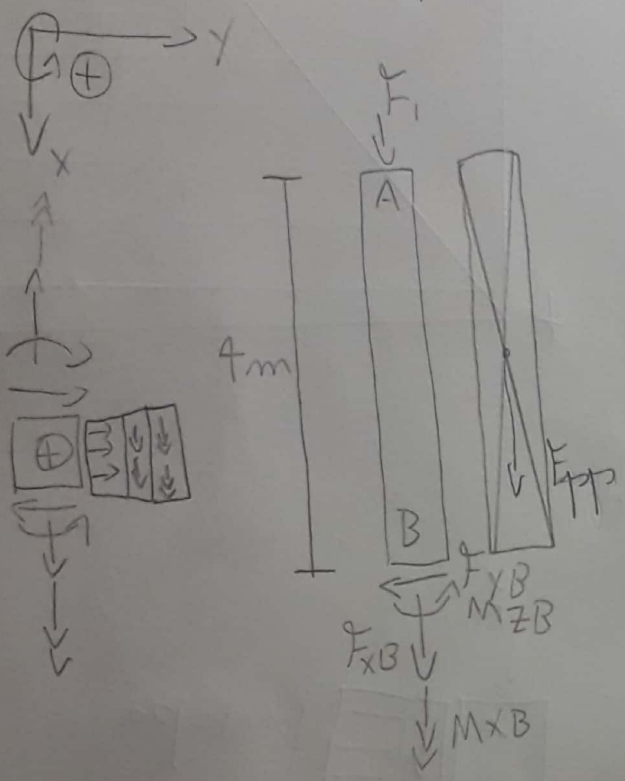
Dados: $L = 2\,m$

$p_0 = 5000\,N/m$

$F_1 = 8000\,N$




## Diagrama de Corpo Livre

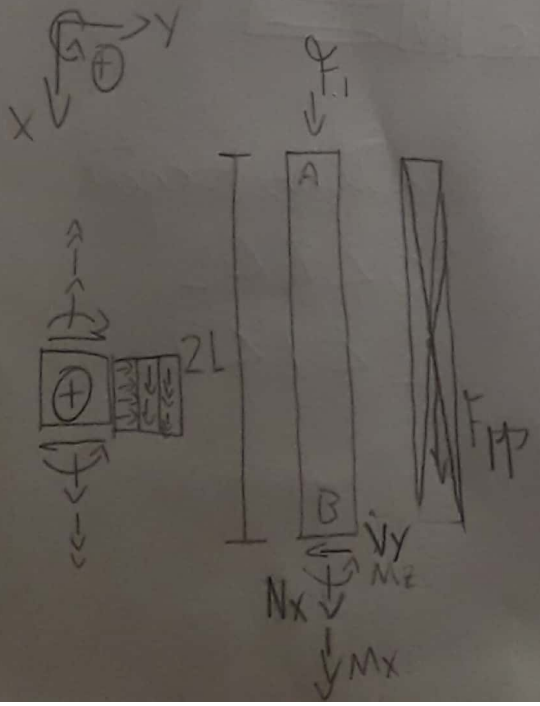



$F_{pp} = p_0 . X$

Número de Secções: 1

$0 < X < 2L$

## Secção AB: $(0 < X < 2L)$




$\sum M_z = 0 \rightarrow \boxed{M_{z(X)} = 0\,N.m}$

$\sum M_x = 0 \rightarrow \boxed{M_{x(X)} = 0\,N.m}$

$\sum F_y = 0 \rightarrow \boxed{V_{y(X)} = 0\,N}$

$\sum F_x = 0 \rightarrow F_1 + N_x + F_{pp} = 0$

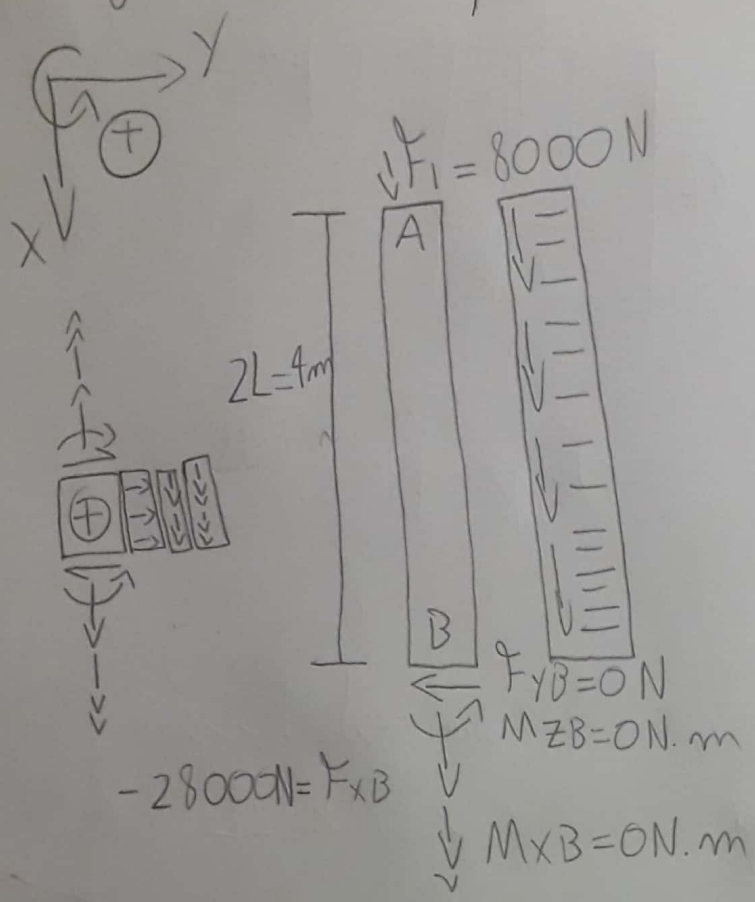
$F_1 + N_x + X.p_0 = 0 \rightarrow N_x = -F_1 - X.p_0$

$N_{x(X)} = -8000 - X.5000$

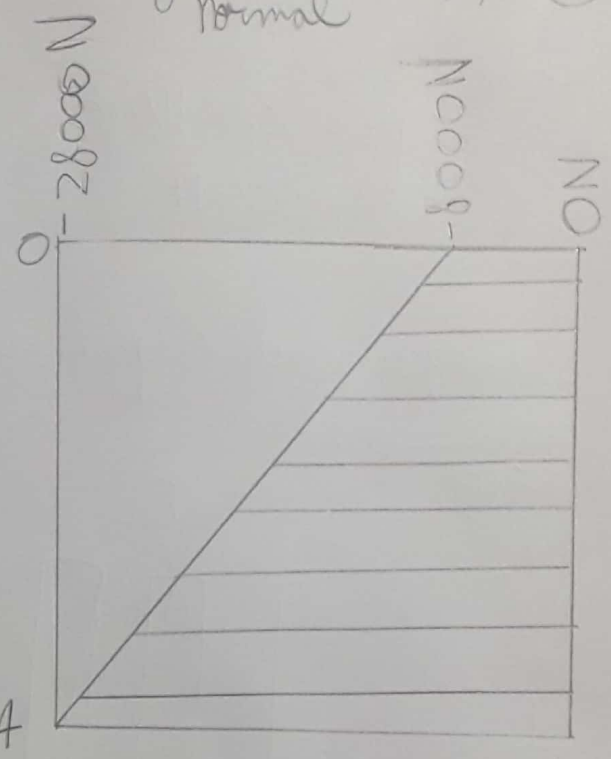
$N_x(0) = -8000\,N$

$N_x(4) = -28000\,N$

## Diagrama de Corpo Livre




## Diagrama de Esforço Normal (2)



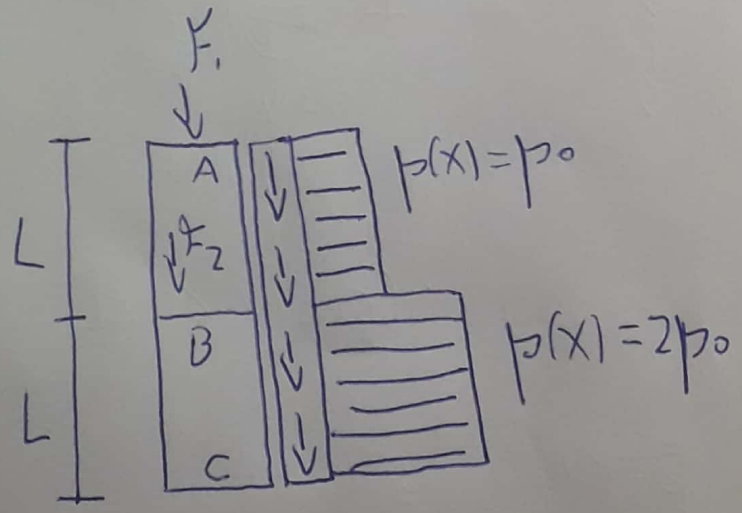

## Ex_MetSec_Axial_04

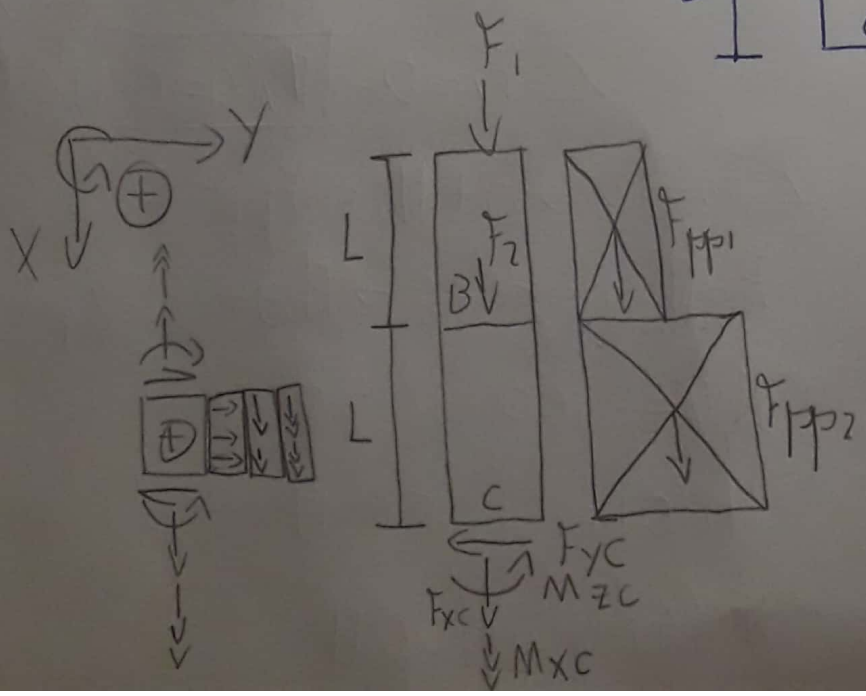
Dados: $L = 2\,m$

$p_0 = 5000\,N/m$

$F_1 = 8000\,N$

$F_2 = 16000\,N$




Duas secções

$0 < X < L$

$L < X < 2L$

$F_{ppp1} = p_0 X$

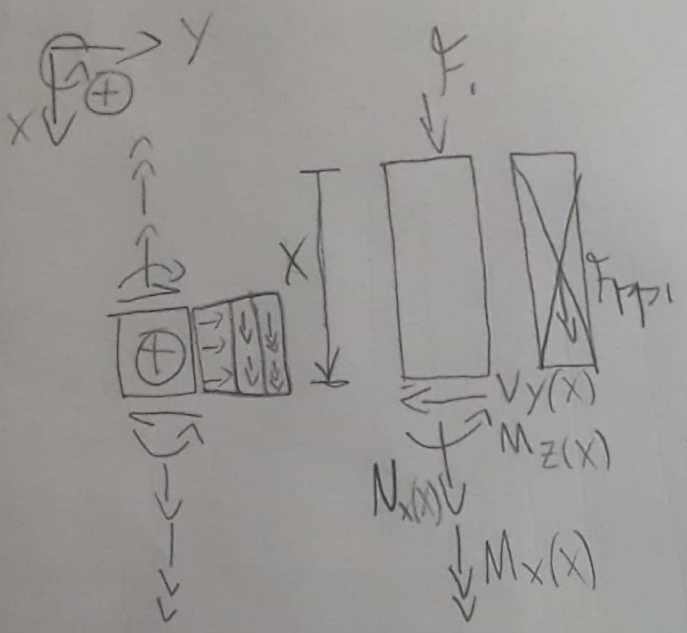
$F_{ppp2} = 2p_0 . X$

Secção AB: $(0 < X < L)$

$\sum F_y = 0 \rightarrow \boxed{V_{y(x)} = 0\ N}$

$\sum M_z = 0 \rightarrow \boxed{M_{z(x)} = 0\ N.m}$

$\sum M_x = 0 \rightarrow \boxed{M_{x(x)} = 0\ N.m}$

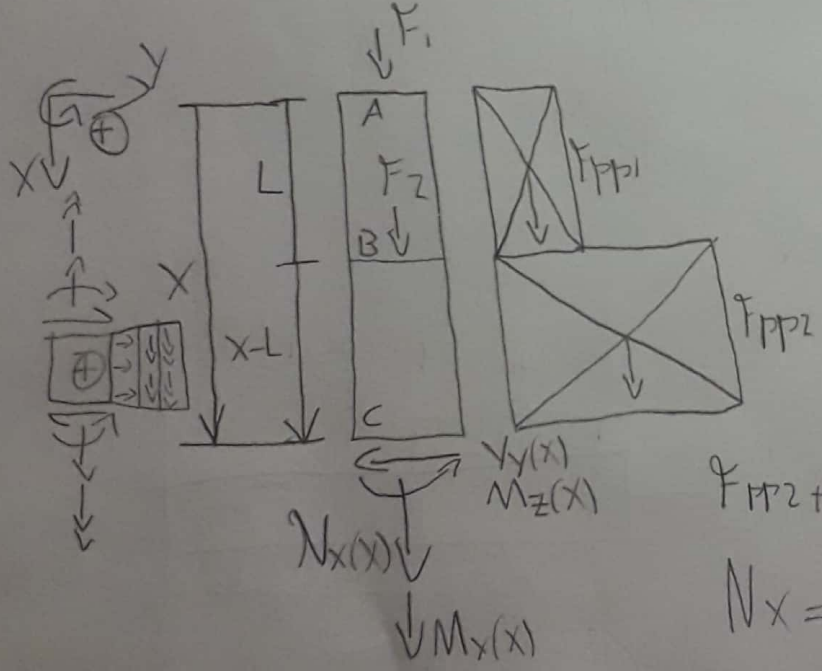



$\sum F_x = 0 \rightarrow F_1 + F_{ppp1} + N_x = 0$

$N_x = -F_1 - F_{ppp1} = -8000 - p_0 \cdot X$

$\boxed{\begin{aligned} N_{x(X)} &= -8000 - 5000X \\ N_{x(0)} &= -8000\ N \\ N_{x(L)} &= -18000\ N \end{aligned}}$

Secção BC: $(L < X < 2L)$




$\sum F_y = 0 \rightarrow \boxed{V_y = 0\ N}$

$\sum M_z = 0 \rightarrow \boxed{M_{z(X)} = 0\ N.m}$

$\sum M_x = 0 \rightarrow \boxed{M_{x(X)} = 0\ N.m}$

$\sum F_x = 0$

$F_{ppp2} + F_1 + F_2 + F_{ppp1} + N_x = 0$

$N_x = -F_1 - F_2 - F_{ppp1} - F_{ppp2}$

$N_x = -8000 - (6000 p_0 L - 2p_0(X-L))$

$N_{x(X)} = -24000 - p_0 L - 2p_0(X-L)$

$N_{x(X)} = -24000 - 5000 \cdot 2 - 2p_0(X-L)$

$\boxed{N_{x(X)} = -34000 - 2p_0(X-L)}$

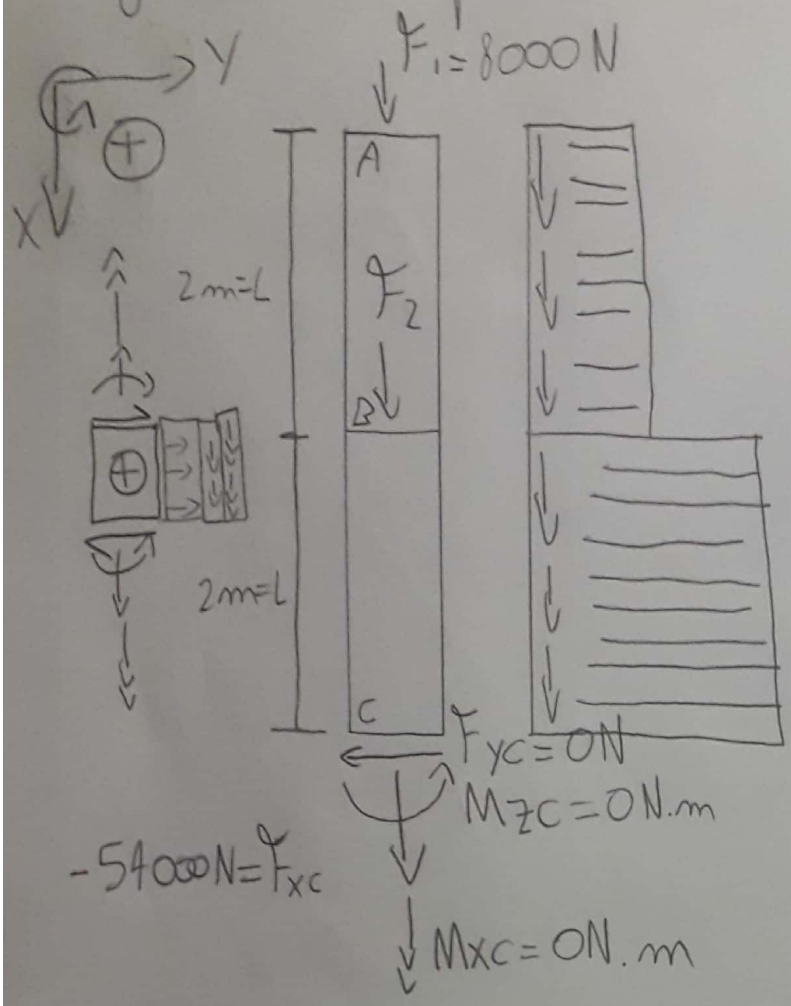
$N_{x(X=L)} = -34000 - 2p_0(L-L)$

$\boxed{N_{x(X=L)} = -34000\ N}$

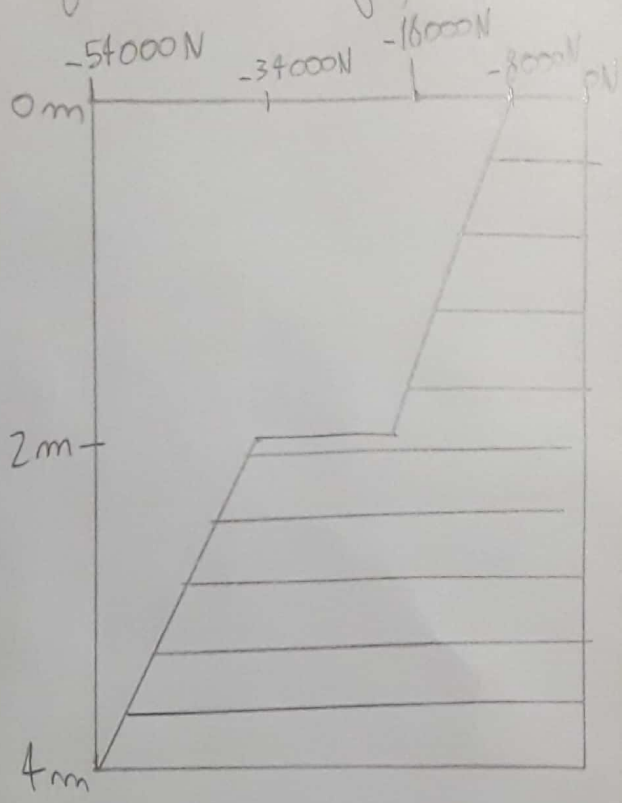
$N_{x(X=2L)} = -34000 - 2p_0(2L-L)$

$N_{x(X=2L)} = -34000 - 2 \cdot 5000 \cdot 2 = \boxed{-54000\ N}$

## Diagrama de Corpo Livre




## Diagrama de Esforço Normal



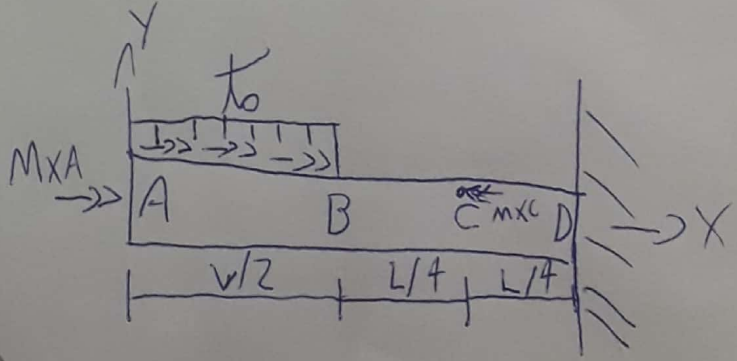

## Exc_MetSec_Torção_03

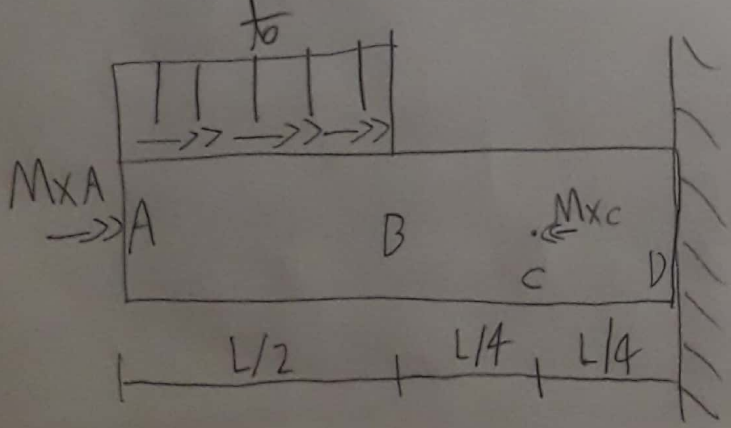
Dados: L = 4m

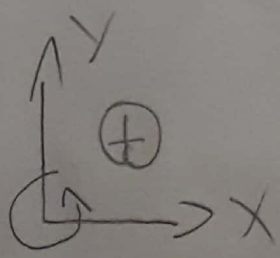
$t_0 = 3000\ N.m/m$

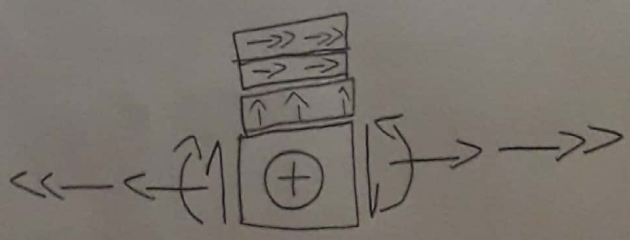
$M_{XA} = 3000\ N.m$

$M_{XC} = 4500\ N.m$



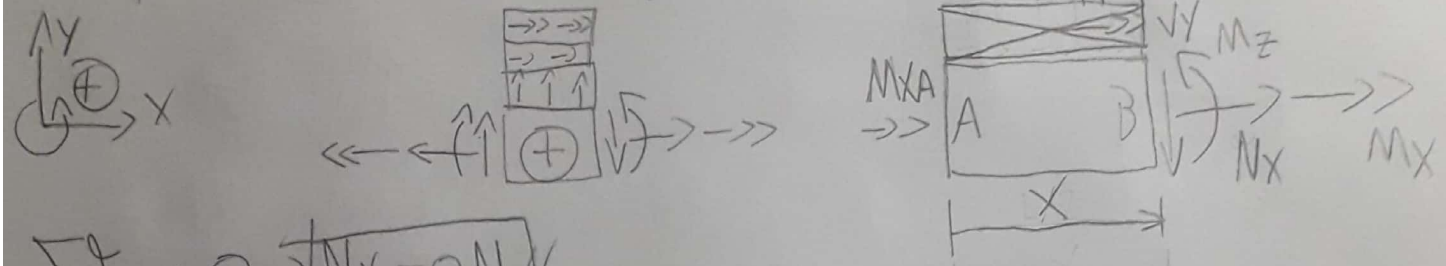
$M_{pp} = t_0 . X$

Número de secções: 3 → $0 < X < L/2$ ;

$L/2 < X < L\,3/4$ ;

$3L/4 < X < L$

## Secção AB: $(0 < X < L/2)$




$\sum F_x = 0 \rightarrow \boxed{N_x = 0\,N}$

$\sum F_y = 0 \rightarrow \boxed{V_y = 0\,N}$

$\sum M_z = 0 \rightarrow \boxed{M_z = 0\,N.m}$

$\sum M_x = 0 \rightarrow +M_{xA} + M_{pp} + M_x = 0$

$M_x = -M_{xA} - M_{pp}$

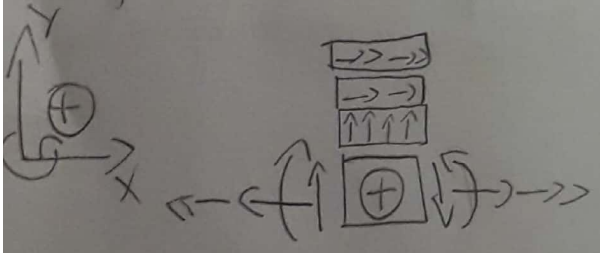
$\boxed{M_x(X) = -3000 - 3000.X}$

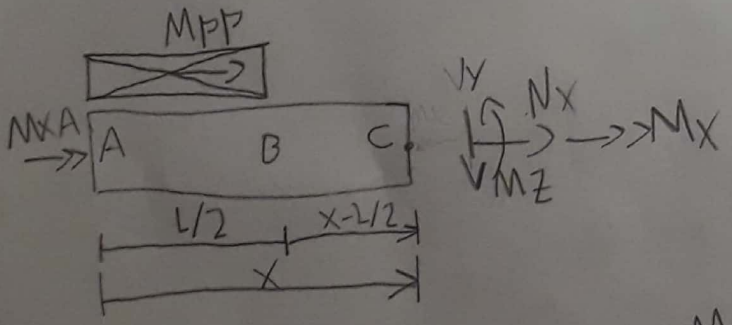
$\boxed{M_x(x=0) = -3000\ N.m}$

$M_x(x = L/2) = -3000 - 3000(4/2)$

$\boxed{M_x(x = L/2) = -9000\ N.m}$

## Secção BC: $(L/2 < X < 3L/4)$




$\sum F_x = 0 \rightarrow \boxed{N_x(x) = 0\,N}$

$\sum F_y = 0 \rightarrow \boxed{V_y(x) = 0\,N}$

$\sum M_z = 0 \rightarrow \boxed{M_z(x) = 0\,N.m}$

$\sum M_x = 0$

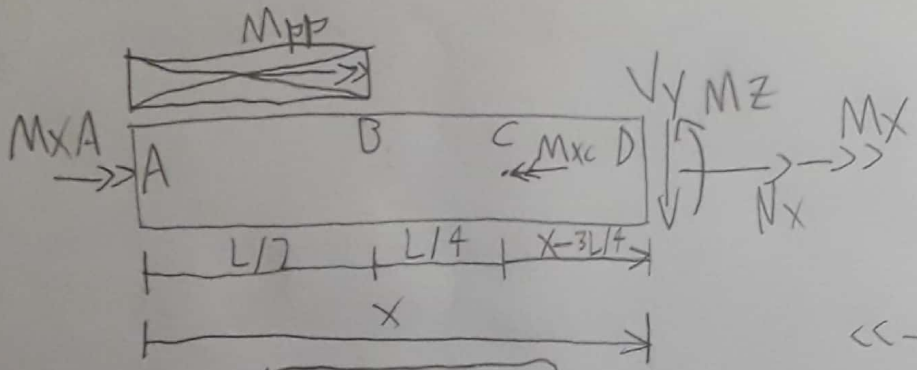
$+M_{xA} + M_{pp} + M_x = 0$

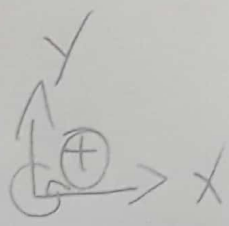
$M_x = +M_{xA} - M_{pp}$

$M_x = -3000 + 3000.L/2$

$\boxed{M_x(X) = -9000\ N.m}$

Secção CD: (3L/4 < X < L)



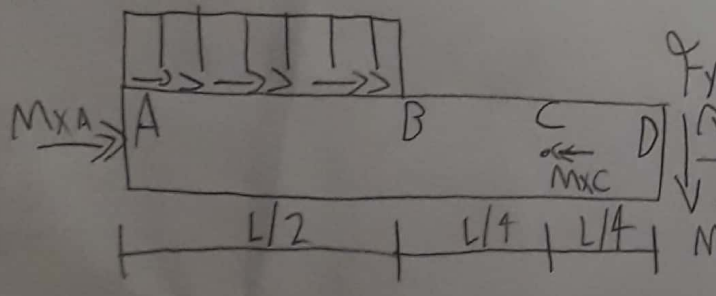

$\sum F_x = 0 \rightarrow \boxed{N_x(X) = 0\ N}$ $\sum F_y = 0 \rightarrow \boxed{V_y(X) = 0\ N}$

$\sum M_z = 0 \rightarrow \boxed{M_z(X) = 0\ N.m}$

$\sum M_x = 0 \rightarrow +M_{xA} - M_{xC} + M_x + M_{pp} = 0$

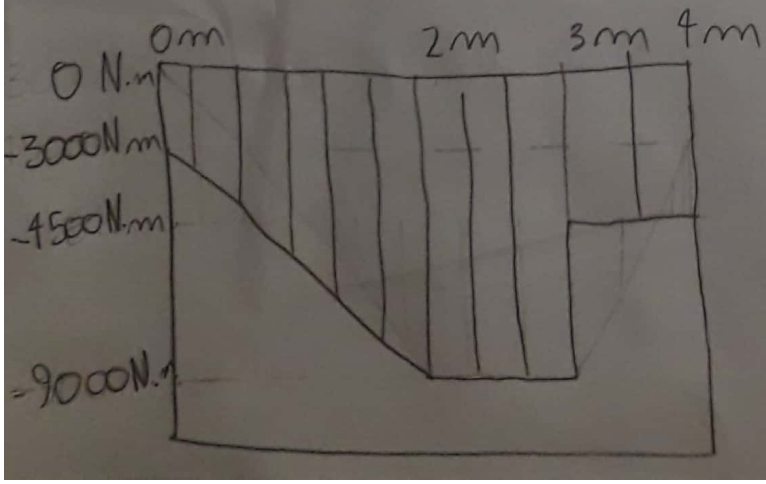
$M_x = -M_{xA} + M_{xC} - M_{pp} = -3000 + 4500 - 3000.(L/2)$

$M_x(X) = 1500 - 3000(L/2) \rightarrow \boxed{M_x(X) = -4500\ N.m}$




$F_{yD} = 0N$ $F_{xD} = 0N$ $M_{zD} = 0N.m$

$M_{xD} = 1500N.m$



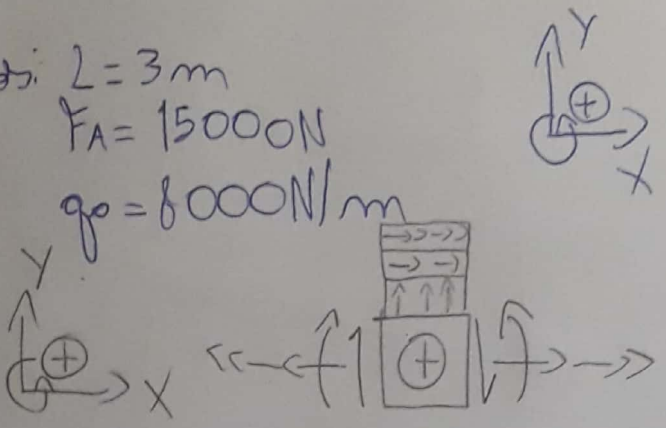
# Exc_metlac_flexão_01

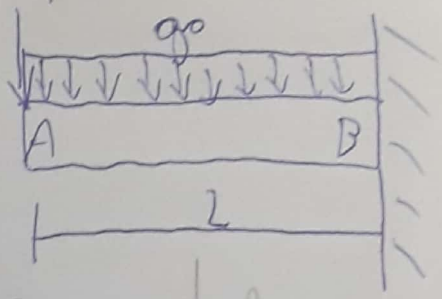


Dados: $L = 3m$

$F_A = 15000N$

$q_0 = 8000N/m$

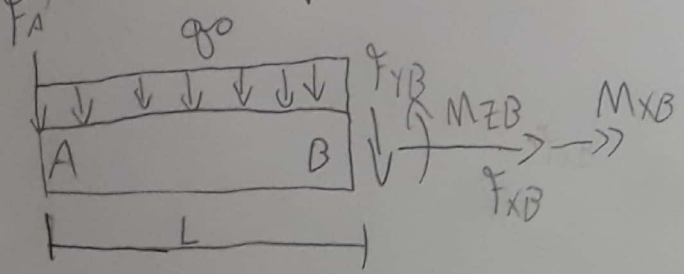



Número de seções: 1

$0 < X < L$

## Reações de apoio




$\sum M_X = 0 \rightarrow \boxed{M_{XB} = 0 N.m}$

$F_{eq} = q_0 \cdot L$

$\sum F_Y = 0$

$-F_A - F_{eq} - F_{YB} = 0$

$F_{YB} = -F_A - F_{eq}$

$F_{YB} = -15000 - 8000.3$

$\boxed{F_{YB} = -39000\ N}$

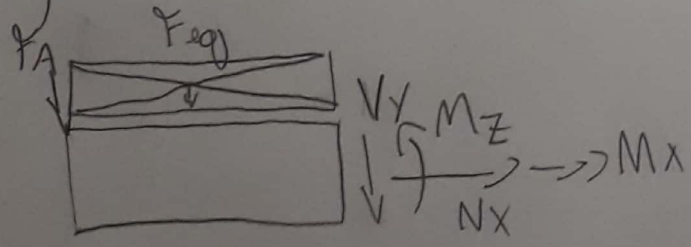
$\sum M_Z = 0$

$M_{ZA} + M_Z + M_{ZB} = 0$

$M_{ZB} = -M_{ZA} - M_Z$

$M_{ZB} = -15000L + 24000.\frac{L}{2} \Rightarrow L = 3 \Rightarrow \boxed{M_{ZB} = 81000\ N.m}$

## Seção AB: $(0 < X < L)$




$\sum F_X = 0 \rightarrow \boxed{N_X(X) = 0N}$

$\sum M_X = 0 \rightarrow \boxed{M_X(X) = 0 N.m}$

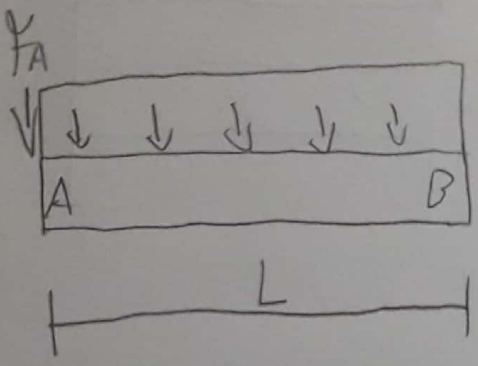
$\sum F_Y = 0 \rightarrow -F_A - V_Y - F_{eq} = 0 \rightarrow V_Y = -F_A - F_{eq} = \boxed{-8000.X - 15000}$

$\boxed{V_Y(X=0) = -15000N}$ $\boxed{V_Y(X=L) = -39000\ N}$

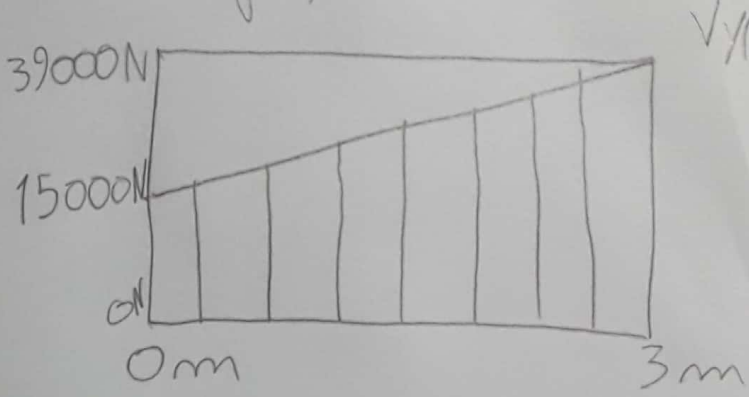
$\sum M_Z = 0 \rightarrow M_{ZA} + M_{Zeq} + M_Z = 0 \rightarrow M_Z = -M_{ZA} - M_{Zeq}$

$M_Z = -F_A.L - q_0.\frac{X^2}{2} \Rightarrow \boxed{M_Z(X) = -4500 - 4000X^2}$

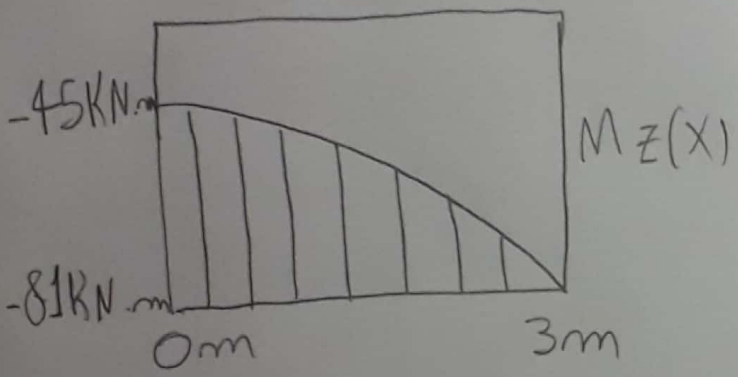
$M_z(X=0) = -45000\ N.m$ | $M_z(X=3) = -81000\ N.m$



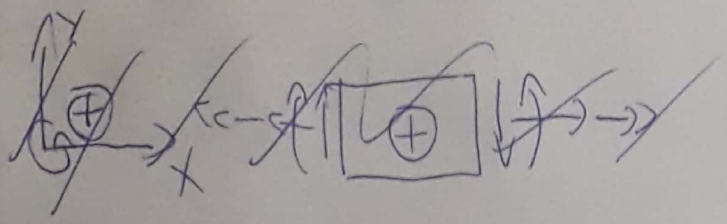

Esforço Cortante



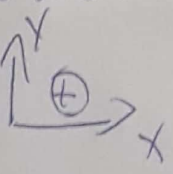

Momento Fletor



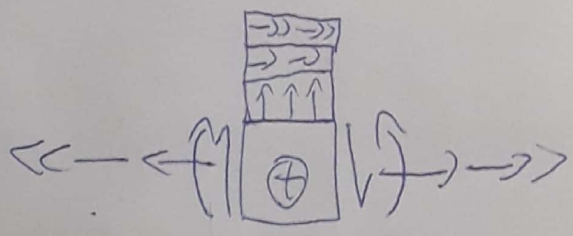
# Exe_Metsec_Flexão_02



Sistemas de coordenadas da estática



Convenção de Resmat



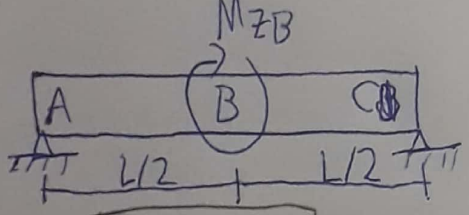
Dados: $L = 2\,m$

$M_{BA} = 5000\,N.m$

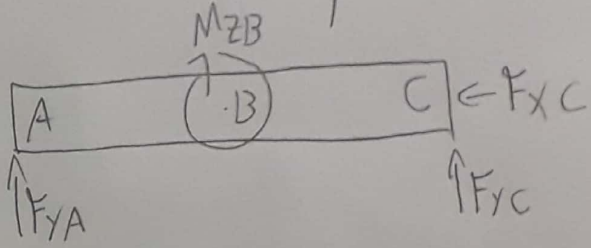
Número de secções: 2

AB $(0 < X < L/2)$

BC $(L/2 < X < L)$




Reações de apoio




$\sum F_x = 0 \rightarrow \boxed{F_{xC} = 0\,N}$

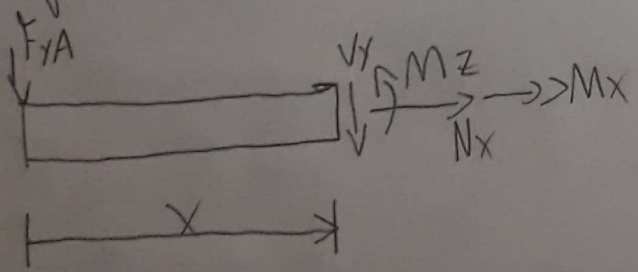
$\sum M_z = 0 \rightarrow -M_{zB} + F_{yC}.L = 0$

$F_{yC} = \frac{M_{zB}}{L} = \frac{5000}{2} = \boxed{2500\,N}$

$\sum F_y = 0 \rightarrow F_{yA} = -F_{yC}$

$\boxed{F_{yA} = -2500\,N}$

Esforços internos: Secção AB: $(0 < X < L/2)$




$\sum F_x = 0 \rightarrow \boxed{N_x(X) = 0\,N}$

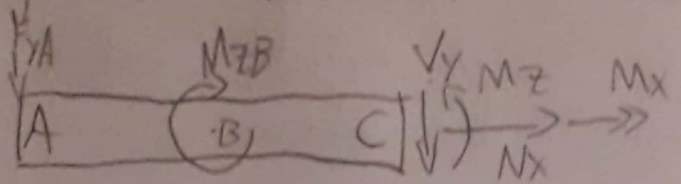
$\sum M_x = 0 \rightarrow \boxed{M_x(X) = 0\,N.m}$

$\sum F_y = 0 \rightarrow -F_{yA} - V_y(X) = 0 \rightarrow \boxed{V_y = -2500\,N}$

$\sum M_z(X) = 0 \rightarrow M_z + F_{yA}.X = 0 \rightarrow -F_A.X = M_z(X) = \boxed{-2500X\,N.m}$

$\boxed{M_z(0) = 0\,N.m}$ $\boxed{M_z(1) = -2500\,N.m}$

Secção BC. $(L/2 < X < L)$




$\sum F_x = 0 \rightarrow \boxed{N_x(X) = 0\,N}$

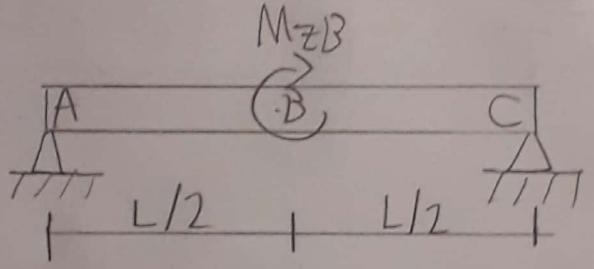
$\sum M_x = 0 \rightarrow \boxed{M_x(x) = 0\,N.m}$

$\sum F_y = 0 \rightarrow -V_y - F_{yA} = 0 \rightarrow \boxed{V_y(X) = -2500\,N}$

$\sum M_z = 0 \rightarrow M_z - M_{zB} + F_{yA}.X = 0 \rightarrow \boxed{M_z = -2500X + 5000}$

$\boxed{M_z(1) = 2500\,N.m}$ $\boxed{M_z(2) = 0\,N.m}$

Diagrama de esforços



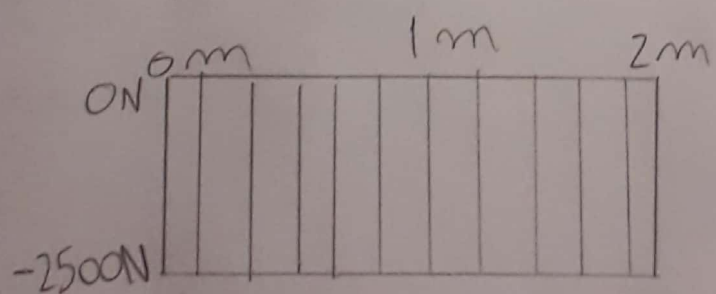




Diagrama da força cortante na direção Y

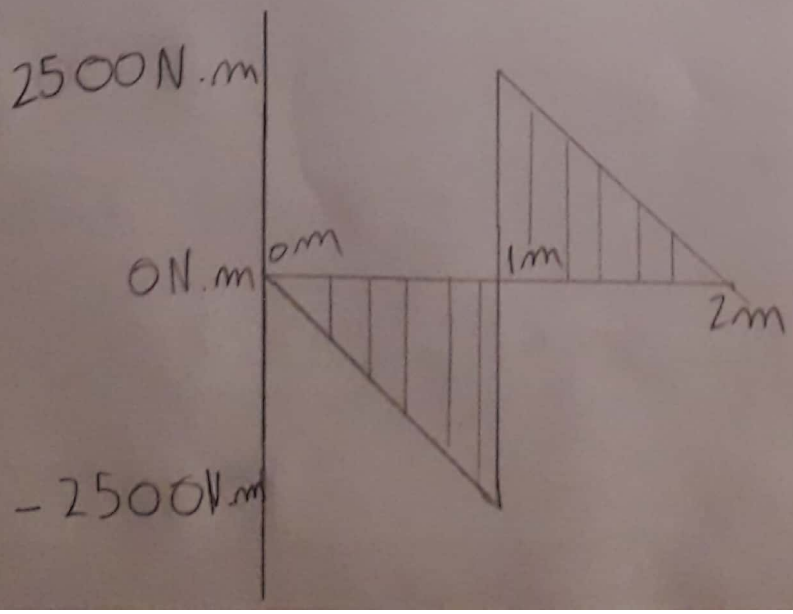



Diagrama do Momento em torno do eixo Z