BUCKLING 02 | THE STRUCTURE SHOWN BELOW IS BUILT OF STEEL ($E = 200\,GPa$) BEAMS OF SQUARE CROSS SECTION (30mm x 30mm).

a. WHICH BAR WILL BUCKLE FIRST?

b. WHAT IS THE

GIVEN:

1. TWO MEMBER STRUCTURE
   - THE MEMBERS ARE PINNED TOGETHER AT ONE JOINT
   - PINNED TO SUPPORTS AT THE OTHER ENDS
2. A LOAD P IS APPLIED AT THE COMMON PIN JOINT

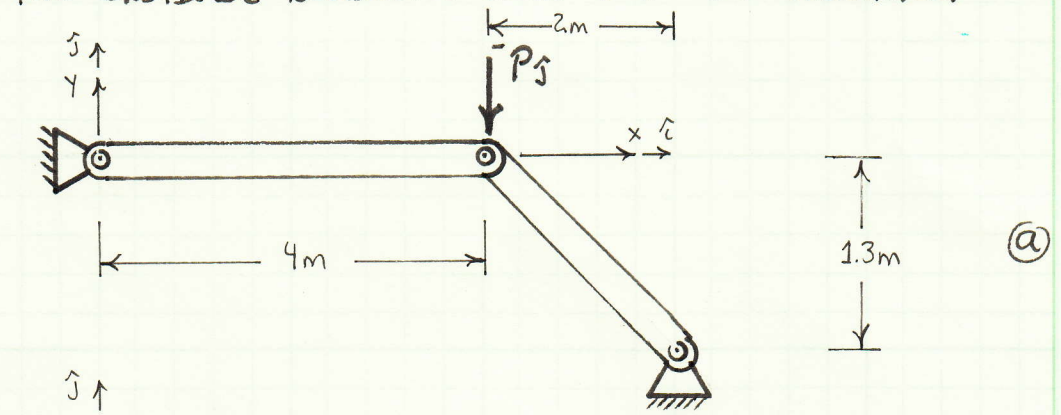
ASSUMPTIONS:

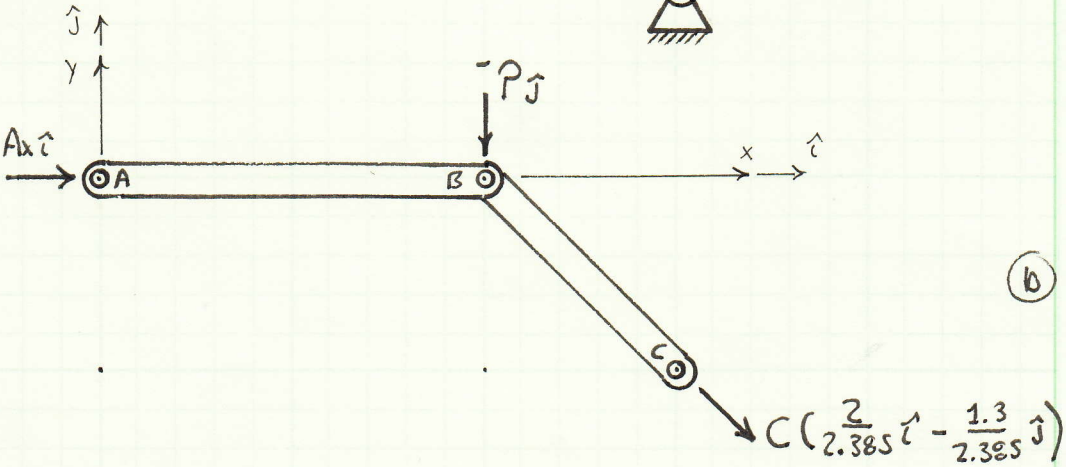
1. MATERIAL IS LINEAR ELASTIC
2. SMALL DEFLECTIONS
3. THE CENTERLINE OF THE MEMBERS INTERSECT AT THE CENTER OF THE COMMON JOINT.
4. THE LOAD IS APPLIED GRADUALLY

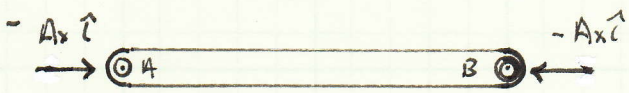
FIND:

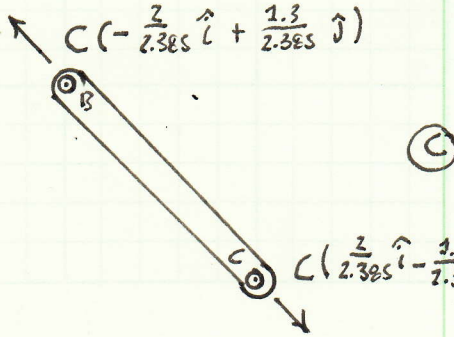
1. DETERMINE WHICH OF THE TWO MEMBERS WILL FAIL FIRST
2. DETERMINE THE CRITICAL BUCKLING LOAD FOR THIS STRUCTURE.

FIGURE:









SOLUTION:

STARTING WITH EQUILIBRIUM ON ~~STRUCTURE~~ THE STRUCTURE IN (b)

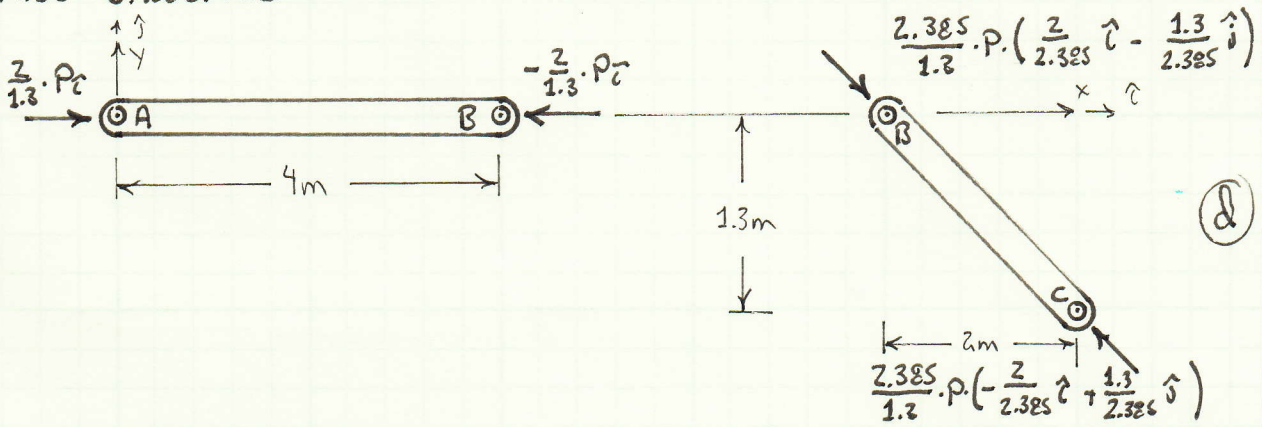
$$\sum F_x = 0 = A_x + \frac{2}{2.385}\cdot C \quad \Rightarrow \quad A = -\frac{2}{2.385}\cdot C \qquad (1)$$

$$\sum F_y = 0 = -P - \frac{1.3}{2.385}\cdot C \quad \Rightarrow \quad \underline{\underline{C = -\frac{2.385}{1.3}\cdot P}} \qquad (2)$$

SUBSTITUTING (2) INTO (1)

$$A = -\frac{2}{2.385}\cdot\left(-\frac{2.385}{1.3}\right)\cdot P = \underline{\underline{\frac{2}{1.3}\cdot P}} \qquad (3)$$

FIGURE (d) ILLUSTRATES THE COMPRESSIVE LOADS ON THE MEMBERS OF THIS STRUCTURE



(d)

BOTH OF THE MEMBERS IN THIS STRUCTURE ARE IN COMPRESSION; THEREFORE, BOTH WILL BE EXAMINED FOR BUCKLING. FOR THE PINNED–PINNED END CONSTRAINTS

$$P_{CR} = \frac{\pi^2}{L^2}EI$$

$$P_{CR,AB} = \frac{\pi^2\cdot E\cdot I}{(4m)^2} = \frac{\pi^2\cdot 200(10^9)\frac{N}{m^2}\cdot\frac{1}{12}(0.030m)^4}{(4m)^2} = 8.328(10^3)N$$

$$\Rightarrow \frac{2}{1.3}P = 8.328(10^3)N \Rightarrow \underline{\underline{P = 5413\cdot N}} \qquad (4)$$

$$P_{CR,BC} = \frac{\pi^2 EI}{((1.3m)^2+(2.0m)^2)} = \frac{\pi^2\cdot 200(10^9)\frac{N}{m^2}\cdot\frac{(0.030m)^4}{12}}{((1.3m)^2+(2.0m)^2)} = 23.42(10^3)N$$

$$\Rightarrow \frac{2.385}{1.3}P = 23.42(10^3)N \Rightarrow \underline{\underline{P = 12\,764\cdot N}} \qquad (5)$$

(4) AND (5) ARE THE VALUES OF THE APPLIED LOAD P THAT PRODUCE BUCKLING IN THE RESPECTIVE MEMBERS. AS SOON AS P = 5413, MEMBER AB BUCKLES.

$\Rightarrow$ **AB BUCKLES FIRST.**

$P_{AB\,BUCKLE} = 5413\,N$

Summary

IN THIS EXAMPLE IT IS ASSUMED THAT THE TWO MEMBERS OF THIS STRUCTURE ARE LONG ENOUGH FOR EULER BUCKLING TO APPLY (i.e.: $\frac{P_{cr}}{A} < \frac{S_y}{2}$). BECAUSE NO YIELD STRENGTH WAS GIVEN. IF THE YIELD STRENGTH WERE KNOWN, THE EULER BUCKLING ASSUMPTION WOULD HAVE TO BE EVALUATED TO SEE IF IT WAS APPROPRIATE FOR THE PRESCRIBED LOADING CONDITION.