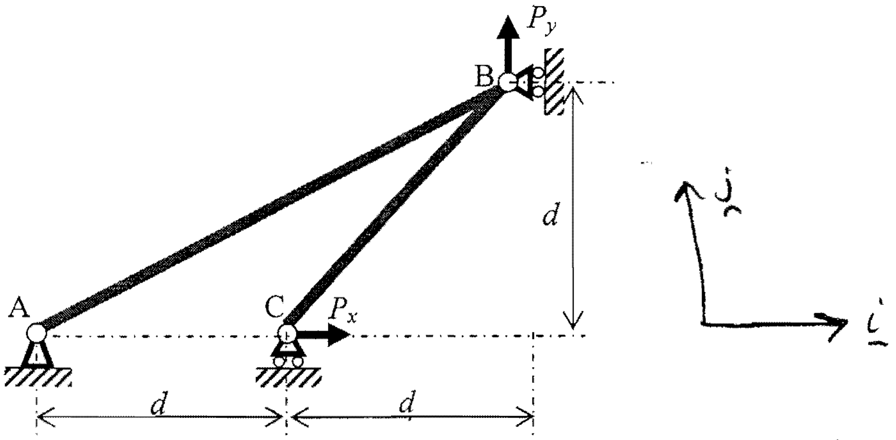
1. A truss is shown below. Both members have identical values of E and A. Joint A is pinned and joints A and C are on roller supports.



a. Is this truss statically determinate, indeterminate, or a mechanism? Why?

$M = 2 \quad J = 3 \quad R = 4 \quad M + J = 2R$ stat det

b. Determine the elongation of each member as functions of the nonzero displacement components of joints B and C. Assume small deflections.

$\delta^{AB} = (\underline{u}^B - \underline{u}^A)\cdot \underline{n}^{AB} \qquad \delta^{BC} = (\underline{u}^C - \underline{u}^B)\cdot \underline{n}^{BC}$

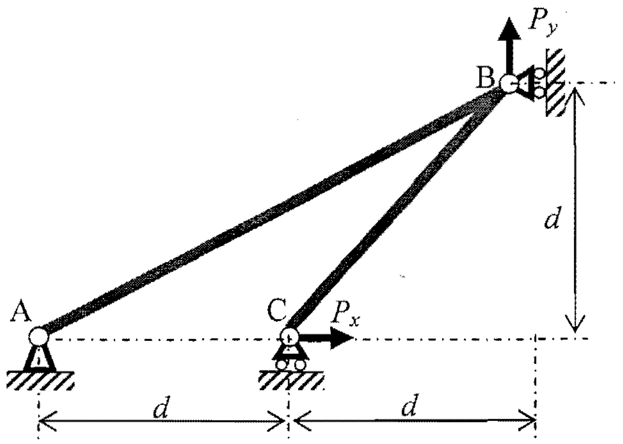
$\underline{n}^{AB} = \frac{1}{\sqrt{5}d}(2d\underline{i} + d\underline{j}) = \frac{1}{\sqrt{5}}(2\underline{i} + \underline{j}) \qquad (L_0^{AB} = \sqrt{5}d)$

$\underline{u}^A = \underline{0} \quad \underline{u}^B = u_y^B \underline{j} \quad (u_x^B = 0)$

$\Rightarrow \delta^{AB} = u_y^B \underline{j} \cdot \frac{1}{\sqrt{5}}(2\underline{i} + \underline{j}) = \boxed{\frac{1}{\sqrt{5}} u_y^B = \delta^{AB}}$

$\underline{n}^{BC} = \frac{1}{\sqrt{2}}(-\underline{i} - \underline{j}) \quad \underline{u}^C = u_x^C \underline{i} \qquad (L_0^{BC} = \sqrt{2}d)$

$\delta^{BC} = (u_x^C \underline{i} - u_y^B \underline{j})\cdot \frac{1}{\sqrt{2}}(-\underline{i} - \underline{j}) = \boxed{\frac{1}{\sqrt{2}}(-u_x^C + u_y^B) = \delta^{BC}}$



PE

c. Find the ~~stiffness matrix~~ for the structure. Use PE.

$$PE: \quad V = \frac{1}{2}\frac{EA}{\sqrt{5}d}(\delta^{AB})^2 + \frac{1}{2}\frac{EA}{\sqrt{2}d}(\delta^{BC})^2 - P_x u_x^C - P_y u_y^B.$$

δ^{AB} & δ^{BC} given in the previous problem

$$V = \frac{1}{2}\frac{EA}{5\sqrt{5}d}(u_y^B)^2 + \frac{1}{2}\frac{EA}{2\sqrt{2}d}(u_y^b - u_x^c)^2 - P_x U_x^C - P_y u_y^B$$

joint displacements

d. Determine the ~~deflections~~ and member forces for the case in which P_x=0. The answers will involve P_y, EA, and d.

Use Maple to solve: $\dfrac{\partial V}{\partial u_x^c} = 0 \quad \dfrac{\partial V}{\partial u_y^b} = 0$

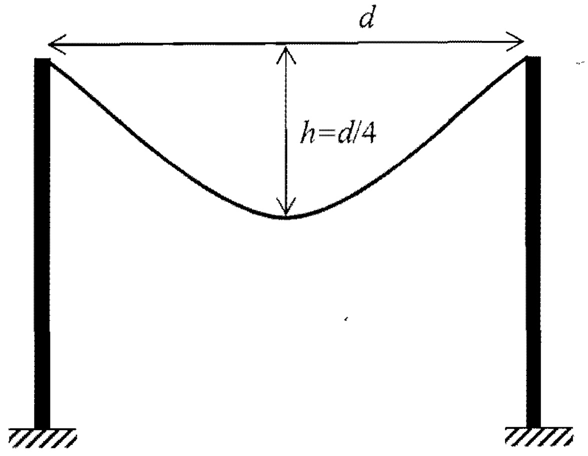
$P_x = 0$ Maple gives $u_x^c = u_y^B = \underline{\dfrac{5\sqrt{5}d}{EA} P_y}$

$$\delta^{AB} = \frac{1}{\sqrt{5}} u_y^B = \frac{5d}{EA} P_y \qquad F^{AB} = \frac{EA}{\sqrt{5}d}\delta^{AB} = \frac{EA}{\sqrt{5}d}\frac{5d}{EA}P_y = \underline{\sqrt{5}P_y}$$

$$\delta^{BC} = \frac{1}{\sqrt{2}}(u_y^b - u_x^c) = 0 \qquad \underline{F^{BC} = 0}$$

2. A uniform, inextensible transmission cable hangs under its own weight. Cable weight per unit length is ω. The desired sag is equal to d/4.

a. Find the cable length required, and the maximum tension T_0 in the cables



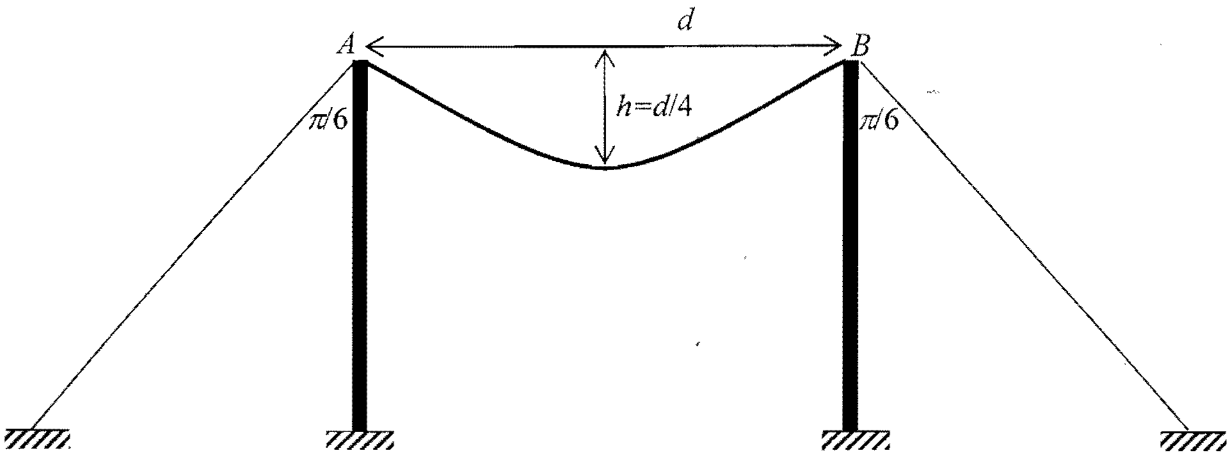
$$L_0/d = \frac{1}{c}\sinh c \qquad \frac{h}{d} = \frac{1}{2c}(\cosh c - 1) \qquad T_0 = \frac{wd}{2c}\cosh c$$

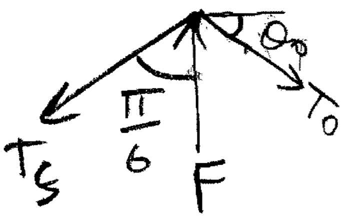
$$\frac{h}{d} = \frac{1}{4} = \frac{1}{2c}(\cosh c - 1) \Rightarrow \underline{c = 0.931}$$

$$\Rightarrow \underline{L_0/d = 1.151}$$

$$\underline{T_0 = 0.787\ wd}$$

b. To avoid bending in the poles, support cables are added as shown to ensure that **the poles carry only axial load**. Determine the tension T_s of the support cables and the resulting compressive force F in the poles. To do this, begin with a free body diagram of the point A at the top of the left-hand pole.





$\theta_0 = \tan^{-1} y'(0) = \tan^{-1}(\sinh c) = 0.82$ radians

$\sum F_x = 0 \quad T_0 \cos\theta_0 = T_s \sin\frac{\pi}{6}$

$\underline{T_s = 1.07\, wd}$

$\sum F_y = 0 \Rightarrow F = T_0 \sin\theta_0 + T_s \cos \pi/6$

$\underline{F = 1.51\, wd}$