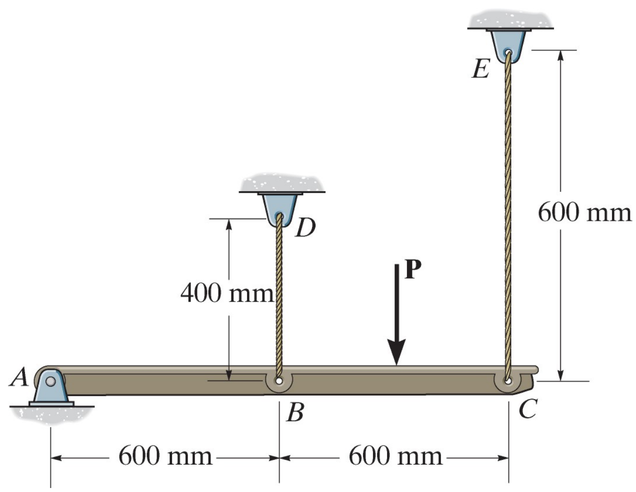
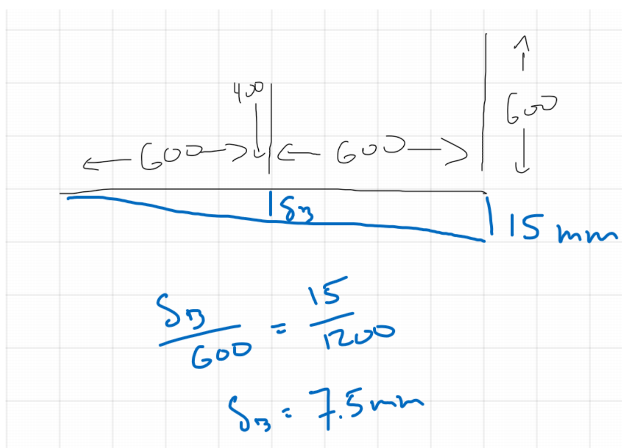
Name:

Homework 2

Due 1 Sep 2020

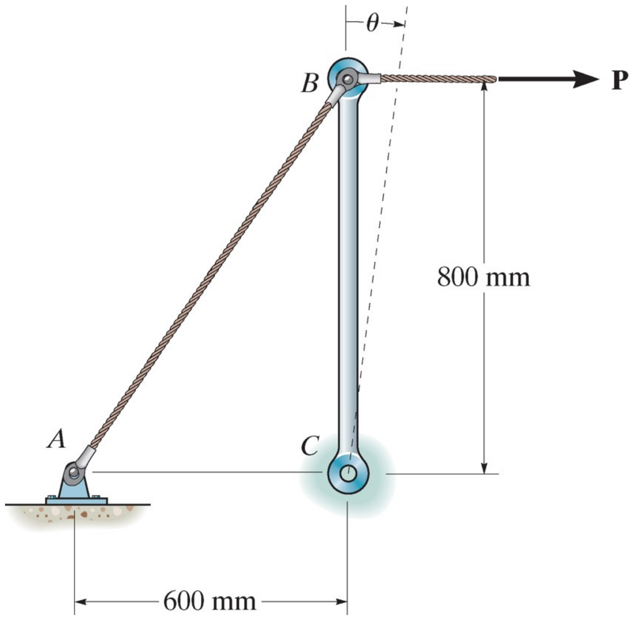
1. If the load shown causes the point C to displace 15 mm find the strain in the ropes BD and CE.

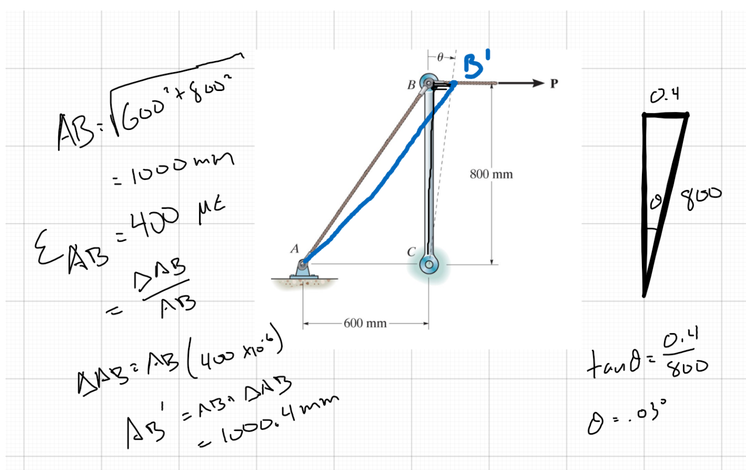




- We use similar triangles to find the displacement at B, $\delta_B = 7.5$ mm
- We can now find the strain in both ropes $\epsilon_{BD} = \frac{7.5}{400} = 0.0188$ and $\epsilon_{CE} = \frac{16}{600} = 0.025$

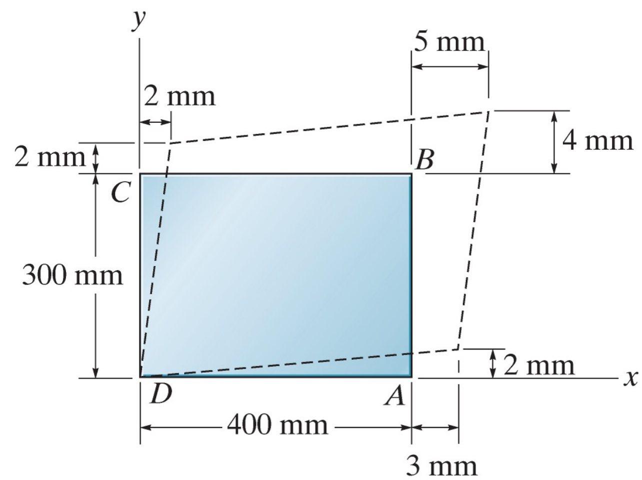
2. A flexible cable, AB, connects to a rigid member CB as part of an airplane control mechanism. A force as shown causes a strain in the cable of $400\mu\epsilon$, find the angle θ that the rigid member rotates due to this strain.

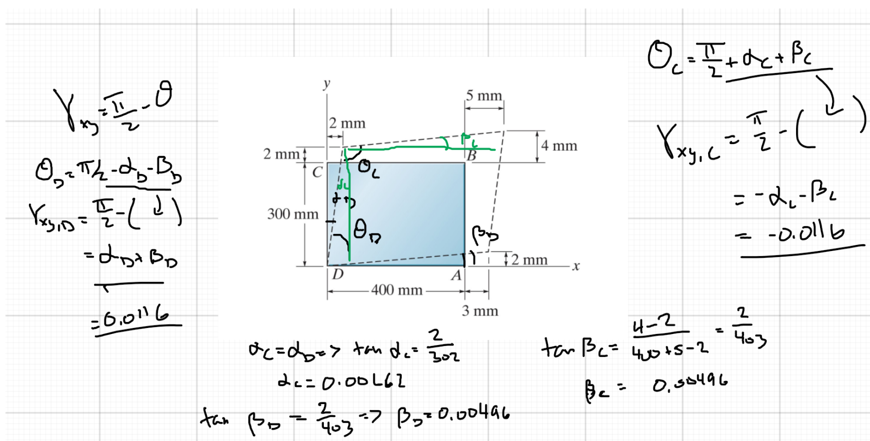




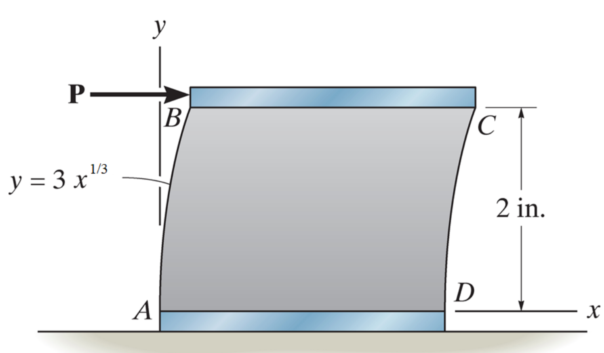
- We see that $\theta = 0.03°$

3. Determine the shear strain, γ_{xy} at corners C and D for the plate shown.



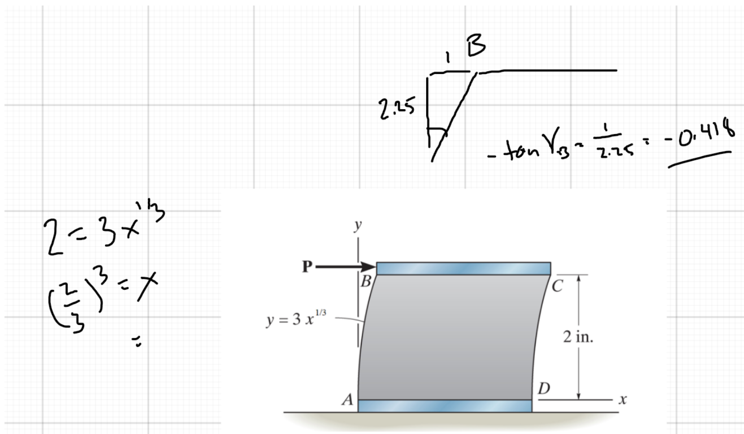


4. The polysulfone block is glued at its top and bottom to rigid plates. A tangential force applied to the top plate causes the sides to deform so that they are described by the equation $y = 3x^{1/3}$. Find the shear strain at corners A and B.



- Since we do not have straight lines, for this problem we need to consider the slope of the curved surface at the two points of interest, A and B.
- We can find these slopes using the derivative

- $y' = x^{-2/3}$
- The next thing we need to determine is the x-coordinate at B (when $y = 2$), we find $x = (2/3)^3 = 0.2963$
- Now we can substitute the two known values of x into the derivative, $y'(0) = \infty$, $y'(0.2963) = 2.25$.
- The slope at A is infinite, meaning a vertical line, which means $\gamma_{xy,A} = 0$
- The slope at B is 2.25, and we can find the associated angle $\gamma_{xy,B} = -0.418$



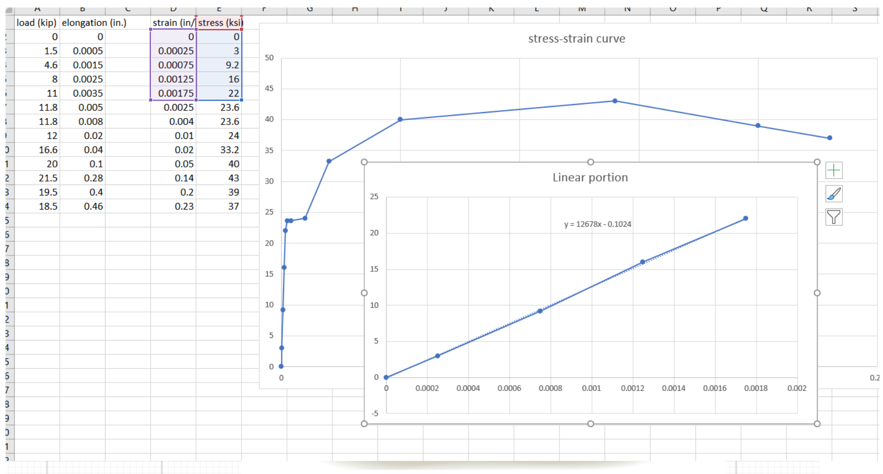
5. A tension test was performed on a steel specimen with a cross-sectional area of 0.5 in^2 and a gage length of 2 in. Plot the stress-strain diagram and find the modulus of elasticity, the yield stress, and the ultimate tensile strength.

Table 1: tensile test data

Load (kip)	**Elongation (in)**
0	0
1.50	0.0005
4.60	0.0015
8.00	0.0025
11.00	0.0035
11.80	0.0050
11.80	0.0080
12.00	0.0200
16.60	0.0400
20.00	0.1000
21.50	0.2800
19.50	0.4000
18.50	0.4600

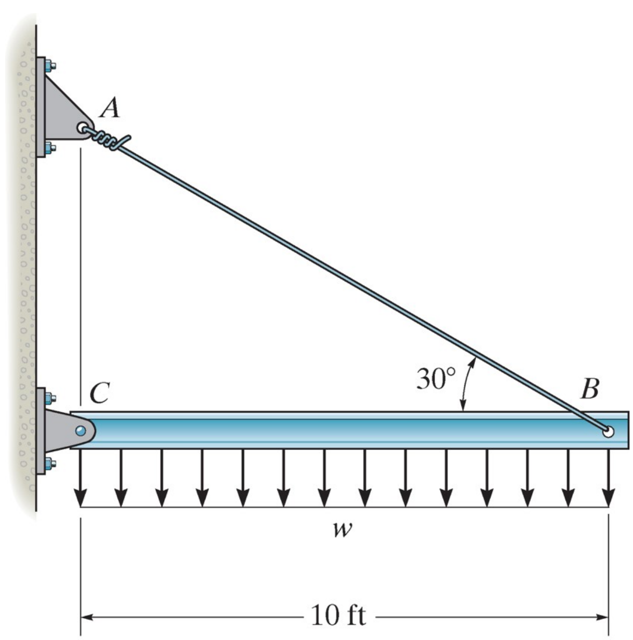
- My solution for this problem was performed in Excel, stress and strain were calculated from the load and elongation, then a best-fit line in the linear region was used to find E and σ_Y, the ultimate tensile strength is the highest stress found.

- $E = 13\,\text{Msi}$, $\sigma_Y = 23.6\,\text{ksi}$, $\sigma_{ult} = 43\,\text{ksi}$



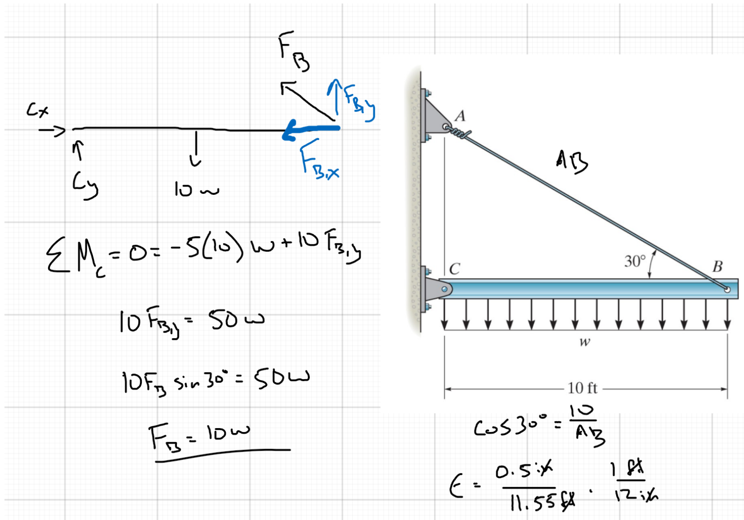
load (kip)	elongation (in.)		strain (in/	stress (ksi)
0	0		0	0
1.5	0.0005		0.00025	3
4.6	0.0015		0.00075	9.2
8	0.0025		0.00125	16
11	0.0035		0.00175	22
11.8	0.005		0.0025	23.6
11.8	0.008		0.004	23.6
12	0.02		0.01	24
16.6	0.04		0.02	33.2
20	0.1		0.05	40
21.5	0.28		0.14	43
19.5	0.4		0.2	39
18.5	0.46		0.23	37

6. The rigid beam shown is supported by a pin at C and an A-36 steel wire AB. If the wire diameter is 0.25 in determine what the load w is when B is displaced 0.50 in downward.



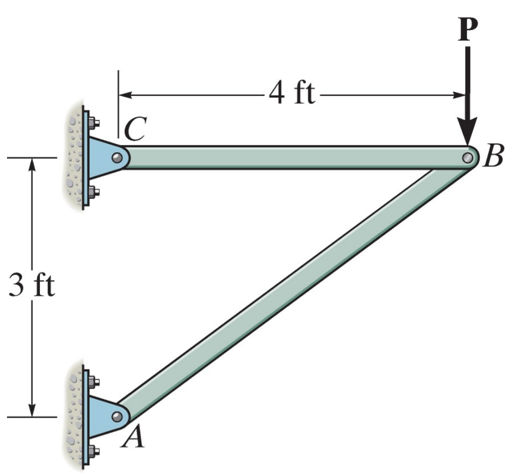
- Since the beam is "rigid" the displacement at B will be entirely due to stretch of the wire.
- We can look up E for A-36 steel in the back cover of the text, $E = 29.0\,\text{Msi}$
- For $\Delta L = 0.5\,\text{in}$ we know that $\epsilon = 0.5/12/11.55 = 0.00361$

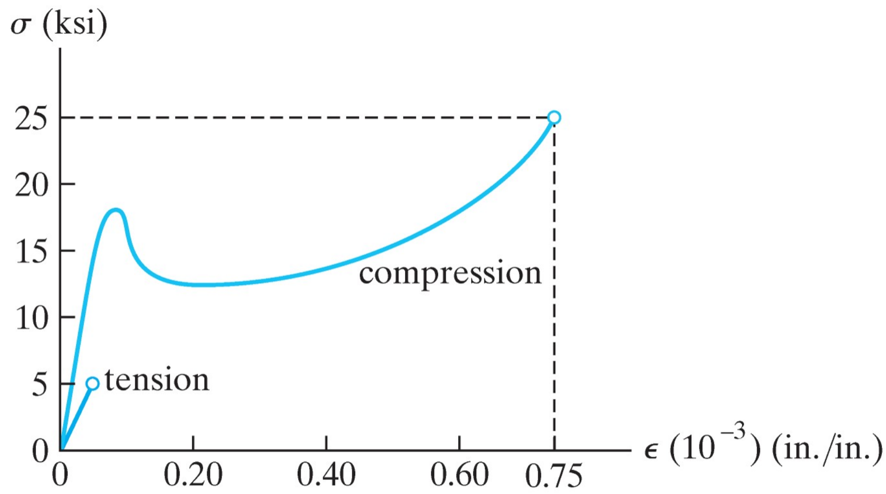
- Using Hook's Law we know that $\sigma = E\epsilon = 29.0\,\text{Msi}.00361$ which gives $\sigma = 104.6\,\text{ksi}$, which for the given diameter means a force of $5.14\,\text{kip}$
- Using statics we can relate the force in the wire to the distributed load



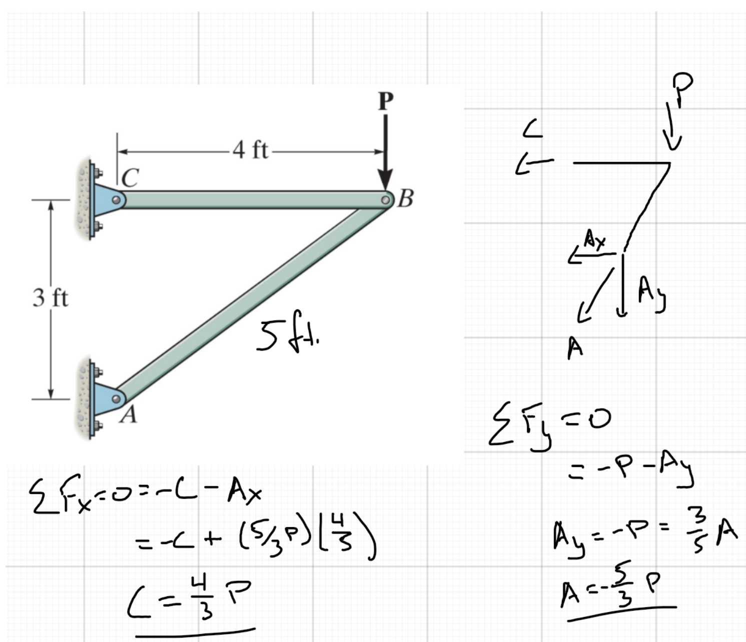
- since $F_B = 5.14\,\text{kip} = 10w$ we know that $w = 514\,\text{lb/ft}$

7. The two bars shown are made from the material given in the stress-strain diagram shown. Find the cross-sectional area of each bar such that they fail under the same load P. Neglect any effects from buckling, consider only tensile and compressive failure.





- We start by doing some statics to determine whether a bar is in tension or compression. Notice that since all forces/reactions occur at pins at the end, these are both 2-force members, so all reaction forces need to act along the axis of the bars



- We see that for a positive P that AB is in compression while BC is in tension. This means that AB will fail at 25 ksi and BC will fail at 5 ksi
- We can now find the areas such that the load P will cause failure in both
- We will find both areas in terms of the unknown load P
- $A_{AB} = 5P/3/25 = \frac{1}{15}P$ where P is in k-lb.
- $A_{BC} = 4P/3/5 = \frac{4}{15}P$ where P is in k-lb., we see that BC needs an area 4 times the size of AB.

8. Dr. Smith made a rubber band gun for his son. If the gun is 9 in long, compare the strain in 0.5 in, 1 in, and 2 in diameter rubber bands when stretched over the barrel of the gun.

   - If the rubber bands are perfectly flexible, and we treat them as folding into nearly a straight line, then their initial length is one-half their circumference
   - The final length will be the length of the rubber band gun, this gives strains of $10.5, 4.7, 1.9$
   - Rubber deforms much more than most engineering materials (steel, aluminum, wood) and thus has much higher strain values than we are used to seeing