**Problem #1:**

**Given:**

The beam shown

**Required:**

The internal forces at point E, located at 2 m from A

**Solution:**

First, we need to calculate the reaction at B. (Why only B?!)  
FBD (1) is drawn below.

\[ \sum M_A = 0 \]  

(Why \( \Sigma M \), not \( \Sigma F \), and why point A?!)  
\( 4B_y - 4.5(2) - 6(0.5) = 0 \)  
\( B_y = 3 \text{ kN (As shown)} \)

Now, we make a section through E and take the right part (Why?!). FBD (2) is drawn.  
Note the assumed directions of the internal forces (Why?!)

\[ w = \frac{2}{3} \Rightarrow w = 2 \text{ kN/m} \]

\[ R = \frac{2(2)}{2} = 2 \text{ kN} \]

Note that the equivalent load \( R \) was calculated after cutting. (Why?!)  
\[ \sum F_y = 0 \Rightarrow [N_E = 0] \]

\[ \sum F_y = 0 \Rightarrow V_E - 2 + 3 = 0 \Rightarrow [V_E = -1 \text{ kN} = 1 \text{ kN} \downarrow] \]

\[ \sum M_E = 0 \]

\( -M_E - 2 \left(\frac{2}{3}\right) + 3(2) = 0 \)

\[ M_E = 4 \frac{2}{3} \text{ kN.m (as shown)} \]
Problem #2:
Given:
The beam shown

Required:
- The reactions
- The internal forces at the center of the beam

Solution:
To be able to find the reactions, we need to separate the beam at B or E. (Why?!) Taking AB, FBD (1) is drawn. Note that there’s no moment at B. (Why?!).

\[ \Sigma M_B = 0 \]
(Why not taking \( \Sigma F_y = 0 \)?)
\[ 3(1) - A_y(3) = 0 \]
\[ \Rightarrow A_y = 1 \text{kN} \uparrow \text{(as shown)} \]

Due to symmetry (in geometry, loads, supports, etc),
\[ F_y = A_y = 1 \text{kN} \uparrow \]

Now, we take FBD (2) for the whole beam.
\[ + \Sigma F_x = 0 \Rightarrow [C_x = 0] \]

\[ \Sigma M_D = 0 \]
\[ \Rightarrow -1(6) + 3(4) - 2C_y + 0.8(4)(1) - 3(2) + 1(4) = 0 \]
\[ \Rightarrow C_y = 3.6 \text{ kN} \uparrow \text{(as shown)} \]

*By symmetry, \[ D_y = C_y = 3.6 \text{ kN} \uparrow \]*

To determine the internal forces at the beam center, a cut (section) is made through that point, and FBD (3) (the left part) is drawn.

\[ + \Sigma F_x = 0 \Rightarrow [N = 0] \]
\[ + \Sigma F_y = 0 \Rightarrow 1 - 3 - 1.6 + 3.6 - V = 0 \Rightarrow [V = 0 \text{ kN}] \]

*This is expected, as it is the value of the shear in the middle/center of a “symmetrical beam”. (Why and how?!)*

\[ \Sigma M = 0 \]
\[ \Rightarrow M - 1(5) + 3(3) + 1.6(1) - 3.6(1) = 0 \]
\[ \Rightarrow M = -2 \text{ kN.m} = 2 \text{ kN.m} \uparrow \]
Problem #3:

Given:

The figure shown

\[ D_{AB} = D_{CD} = 20 \text{ mm}; \ D_{BC} = 40 \text{ mm} \]

Required:

\( \sigma \) in AB, BC, and CD

Solution:

\[ \sigma = \frac{P}{A} = \frac{N}{A} \]

\( N \) is the internal normal force, obtained by passing a cut (section) through the part of interest. A section through each of AB, BC, and CD is made, and the “easier” part (left or right) is taken and an FBD is drawn, as shown below.

\[ (N_A \text{ may be assumed in the other direction } \leftarrow, \ i.e., \ compression.) \]

\[ \sum F_x = 0 \ \Rightarrow \ 10 + N_{AB} = 0 \ \Rightarrow \]

\[ N_{AB} = -10 \text{ kN} = 10 \text{ kN} \ \leftarrow = 10 \text{ kN} "C" \]

\[ \sigma_{AB} = \left( \frac{N}{A} \right)_{AB} = \frac{-10(10)^3}{\pi/4(20)^2} \ \Rightarrow \]

\[ \sigma_{AB} = -31.83 \text{ MPa} = 31.83 \text{ MPa } "C" \]

*Be careful about the units (N, m, mm, Pa, MPa,...)
\[ \Sigma F_x = 0 \Rightarrow 10 - 10 - 10 + N_{BC} = 0 \Rightarrow \]

\[ N_{BC} = 10 \text{ kN} \text{ "T"} \]

\[ \sigma_{BC} = \left( \frac{N}{A} \right)_{BC} = \frac{10(10)^3}{\pi/4 (40)^2} \Rightarrow \]

\[ \sigma_{BC} = 7.958 \text{ MPa "T"} \]

\[ N_{CD} \quad \text{20 kN} \quad \text{(Assumed "T", may as well be assumed "C")} \]

\[ \Sigma F_x = 0 \Rightarrow -20 - N_{CD} = 0 \Rightarrow \]

\[ N_{CD} = -20 \text{ kN} = 20 \text{ kN "C"} \]

\[ \sigma_{CD} = \left( \frac{N}{A} \right)_{CD} = \frac{-20(10)^3}{\pi/4 (20)^2} \Rightarrow \]

\[ \sigma_{CD} = -63.66 \text{ MPa} = 63.66 \text{ MPa "C"} \]
Problem #4:

Given:

The figure shown

\( A_{\text{cable}} = 20 \text{ mm}^2 \)

Required:

\( \sigma \) in the cables.

Solution:

In order to determine the stresses in the cables, we need to find the internal normal forces in these cables as \( \sigma = \frac{N}{A} \) where \( N \) is the internal force.

FBD (1) is drawn for AB. (Why?!)
Now, FBD (2) for DC is drawn.

(Another FBD for both AB and DC can be drawn. Why and how?!)