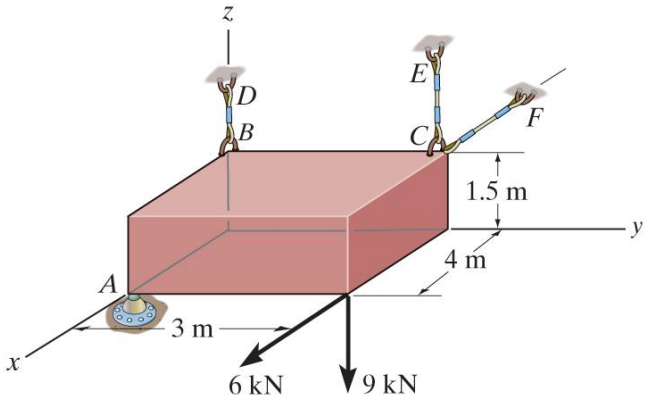
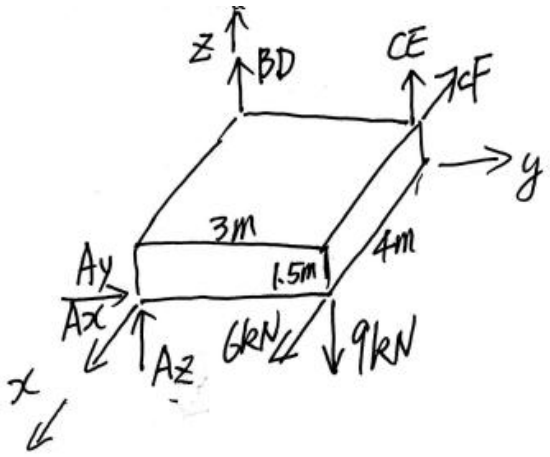
ENSC 2113 – Fall 2023 Homework #7

Problem #1 (15 pts):

Draw the free-body diagram of the system and calculate the reaction forces at the ball-and-joint A and the tensile force in cables CE, and CF, and in the link BD.





$\Sigma M_x(\bar{F})=0$

$CE\cdot 3-9\cdot 3=0$ $\boxed{CE=9\,kN}$

$\Sigma F_y=0$

$\boxed{A_y=0}$

$\Sigma M_z(\bar{F})=0$

$CF\cdot 3-6\times 3=0$ $\boxed{CF=6\,kN}$

$\Sigma F_x=0$ $A_x-CF+6=0$ $\boxed{A_x=0}$

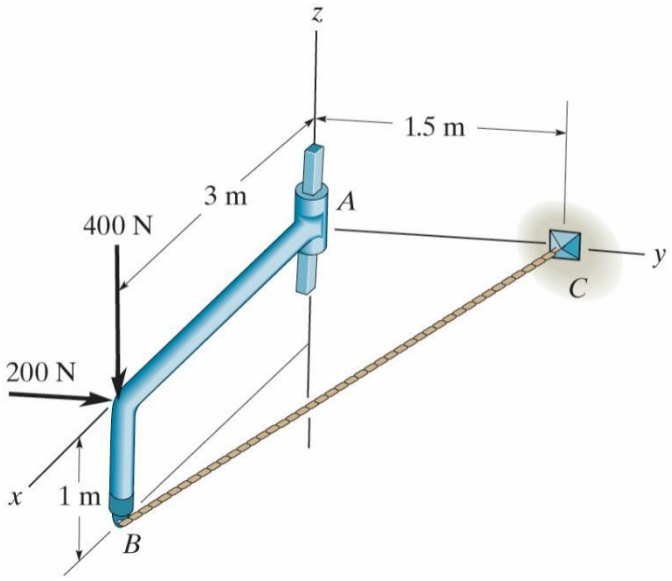
$\Sigma M_y(\bar{F})=0$ $-A_z\cdot 4+9\times 4-CF\times 1.5=0$

$\boxed{A_z=6.75\,kN}$

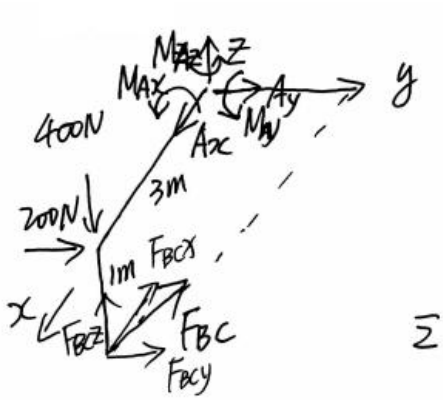
$\Sigma F_z=0$ $BD+CE+A_z-9=0$

$\boxed{BD=-A_z=-6.75\,kN}$

Problem #2 (20 pts):



Draw the free-body diagram of the system and calculate the support reactions at the square shaft at A and the tensile force in cable BC. The shaft is free to move along the z-axis.



$B(3,0,-1)$ $C(0,1.5,0)$

$\vec{r}_{BC} = (-3, 1.5, 1)$ $|r_{BC}| = \sqrt{(-3)^2+1.5^2+1} = 3.5\,m$

$\vec{u}_{BC} = (-\frac{6}{7}\vec{i} + \frac{3}{7}\vec{j} + \frac{2}{7}\vec{k})$

$\vec{F}_{BC} = F_{BC}(-\frac{6}{7}\vec{i} + \frac{3}{7}\vec{j} + \frac{2}{7}\vec{k})$

$\Sigma F_z = 0$ $-400 + \frac{2}{7}F_{BC} = 0$ $F_{BC} = 1400N$

So $\vec{F}_{BC} = (-1200\vec{i} + 600\vec{j} + 400\vec{k})$.

$\Sigma F_y = 0$ $A_y + 200 + F_{BCy} = 0$ $\boxed{A_y = -800\,N\ (\leftarrow)}$

$\Sigma F_x = 0$ $A_x + F_{BCx} = 0$ $A_x - 1200 = 0$ $\boxed{A_x = 1200N\ (\swarrow)}$

$\Sigma M_x(\bar{F}) = 0$ $M_{Ax} + F_{BCy} \cdot 1 = 0$ $\boxed{M_{Ax} = -600\,N\cdot m}$

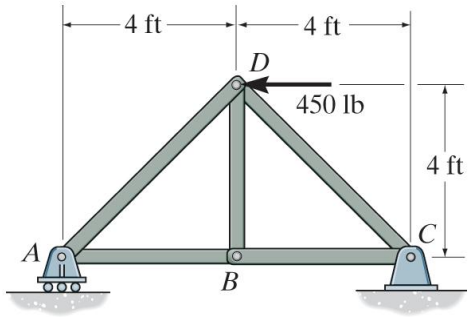
$\Sigma M_y(\bar{F}) = 0$ $M_{Ay} + 400 \times 3 - F_{BCz} \cdot 3 + F_{BCx} \cdot 1 = 0$

$\boxed{M_{Ay} = -1200\,N\cdot m}$

$\Sigma M_z(\bar{F}) = 0$ $M_{Az} + 200 \times 3 + F_{BCy} \cdot 3 = 0$

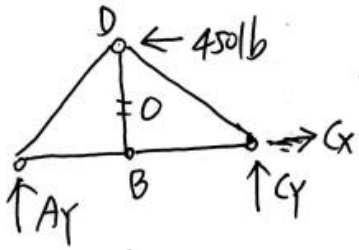
$\boxed{M_{Az} = -2400\,N\cdot m}$

Problem #3 (15 pts):



Calculate the external support reactions and determine the force in each of the truss members utilizing the method of joints. Draw the free-body diagram of the full system and each joint free-body diagram. Identify any zero-force members and label each force as tension or compression.

ΣF_M: BD



Entire FBD

$\rightarrow \Sigma F_x = 0 \quad +Cx - 450 = 0 \quad Cx = 450lb(\rightarrow)$

$\circlearrowleft \Sigma M_C(\vec{F}) = 0 \quad 450 \times 4 - Ay \times 4 = 0$

$Ay = 225lb(\uparrow)$

$\uparrow \Sigma F_y = 0 \quad Ay + Cy = 0 \quad Cy = -225lb(\downarrow)$

FBD @ A

$\uparrow \Sigma F_y = 0$

$AD\cos 45° + 225 = 0$

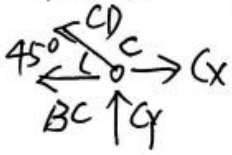
$AD = -318.2lb(C)$

$\rightarrow \Sigma F_x = 0$

$AD\sin 45° + AB = 0$

$AB = 225lb(T)$

FBD @ C



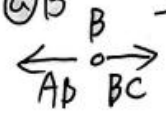
$\uparrow \Sigma F_y = 0$

$CD\cos 45° + Cy = 0$

$CD = -Cy\sqrt{2}$

$= 318.2lb(T)$

FBD @ B



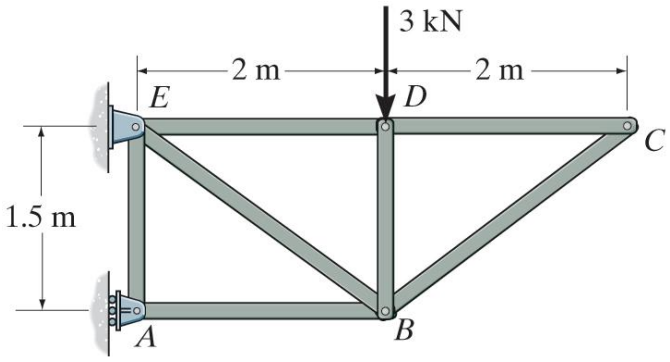
$\rightarrow \Sigma F_x = 0$

$BC - AB = 0$

$BC = AB = 225lb(T)$

FBD @ D

Problem #4 (20 pts):



Determine the force in each of the truss members using method of joints. Draw all pertinent free-body diagrams and indicate tension or compression for the internal forces. Identify any zero-force members.

ΣM: CD / CB (and DE / AE)

FBD @ D

3kN, DE, BD

$\pm \rightarrow \Sigma F_x = 0$ | $DE = 0$

$+\uparrow \Sigma F_y = 0$ $\quad -3 - BD = 0$ $\quad BD = -3\,kN$

$BD = 3\,kN\,(C)$

FBD @ B

BE, BD, AB (4, 3, 5)

$+\uparrow \Sigma F_y = 0$ $\quad BD + \frac{3}{5}BE = 0$ $\quad BE = -\frac{5}{3}BD = 5\,kN\,(T)$

$\pm \rightarrow \Sigma F_x = 0$ $\quad -AB - BE \cdot \frac{4}{5} = 0$ $\quad AB = -\frac{4}{5}BE = -4\,kN$

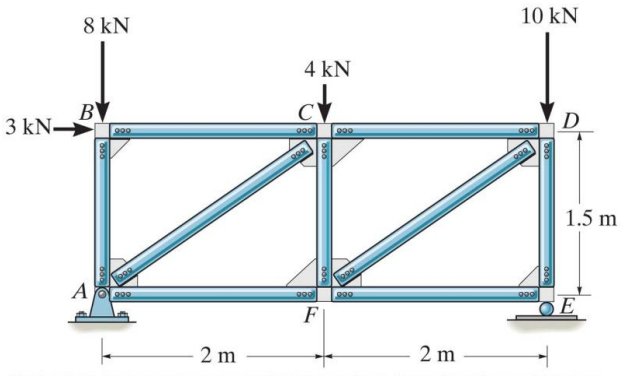
$AB = 4\,kN\,(C)$

FBD @ A

AE, AB, Ax

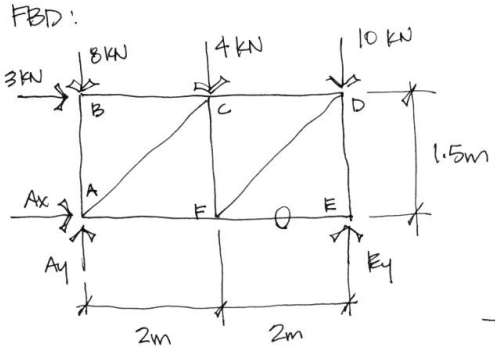
$\Sigma F_y = 0$ | $AE = 0$

Problem #5 (20 pts):



Determine the force in each of the truss members using method of joints. Draw all pertinent free-body diagrams and indicate tension or compression for the internal forces. Identify any zero-force members.

FBD:



$+\circlearrowleft \Sigma M_A = 0 = -3(1.5) - 4(2) - 10(4) + E_y(4\,m)$

$E_y = 13.125\ kN \uparrow$

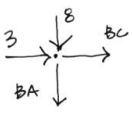
$+\uparrow \Sigma F_y = 0 = A_y - 8 - 4 - 10 + 13.125$

$A_y = 8.875\ kN \uparrow$

$+\rightarrow \Sigma F_x = 0 = A_x + 3$

$A_x = 3\ kN \leftarrow$

JOINT B:



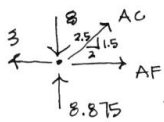
$+\uparrow \Sigma F_y = 0 = -8 - BA$

$\boxed{BA = 8\ kN\ (c)}$

$+\rightarrow \Sigma F_x = 0 = 3 + BC$

$\boxed{BC = 3\ kN\ (c)}$

JOINT A:



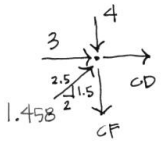
$+\uparrow \Sigma F_y = 0 = -8 + 8.875 + \frac{1.5}{2.5} AC$

$\boxed{AC = 1.458\ kN\ (c)}$

$+\rightarrow \Sigma F_x = 0 = -3 + \frac{2}{2.5}(-1.458) + AF$

$\boxed{AF = 4.17\ kN\ (T)}$

JOINT C:



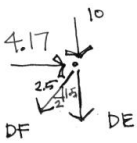
$+\rightarrow \Sigma F_x = 0 = 3 + CD + \frac{2}{2.5}(1.458)$

$\boxed{CD = 4.17\ kN\ (c)}$

$+\uparrow \Sigma F_y = 0 = -4 + \frac{1.5}{2.5}(1.458) - CF$

$\boxed{CF = 3.125\ kN\ (c)}$

JOINT D:



$+\rightarrow \Sigma F_x = 0 = 4.17 - \frac{2}{2.5} DF$

$\boxed{DF = 5.21\ kN\ (T)}$

$+\uparrow \Sigma F_y = 0 = -10 - \frac{1.5}{2.5}(5.21) - DE$

$\boxed{DE = 13.125\ kN\ (c)}$

$\boxed{\Sigma F_M:\ EF}$