CE 201 STATICS (Sections A & 6)

First Semester (081)

H.W. #9 Solutions

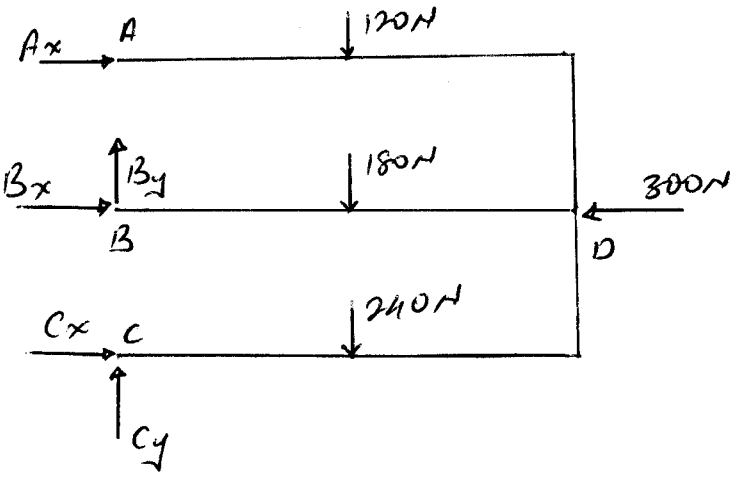
Problem 1

Given: Figure P1 of a frame in the question sheet.

Required: The forces on the members of the frame.

Solution.

First FBD of the whole frame is drawn.



FBD (1)

In FBD (2),

$+\circlearrowleft \sum M_D = 0 \Rightarrow$

$\Rightarrow -A_x(0.3) + 120(0.4) = 0$

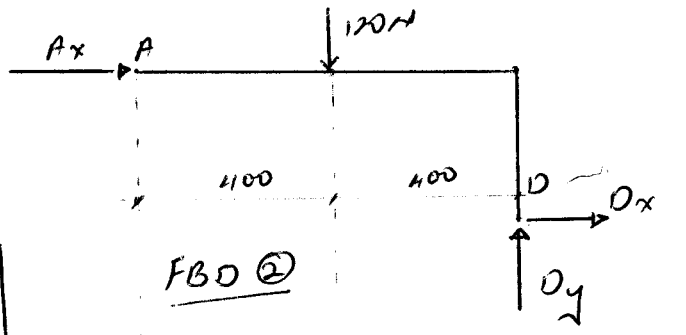
$\Rightarrow \boxed{A_x = 160\,N \leftarrow}$

$\pm \sum F_x = 0 \Rightarrow A_x + D_x = 0$

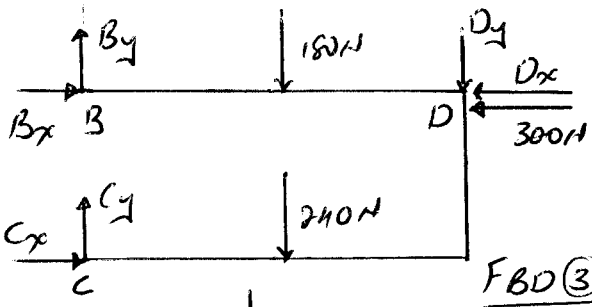
$\Rightarrow \boxed{D_x = -160\,N = 160\,N \leftarrow}$

$+\uparrow \sum F_y = 0 \Rightarrow D_y - 120 = 0$

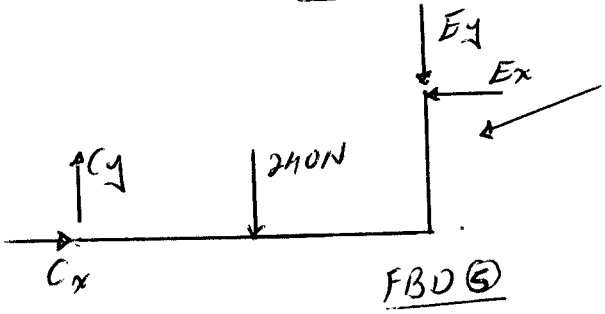
$\Rightarrow \boxed{D_y = 120\,N \uparrow}$



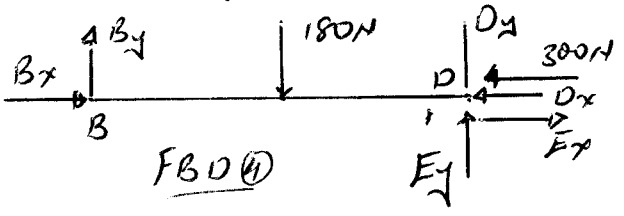
FBD (2)



FBD (3)



FBD (5)



FBD (4)

Note that the 300N force can be placed on any of the members at D. (Why??!!)

Study carefully joint D in FBD's ③, ④ and ⑤ and think why(?!!).

Also note that D_x and D_y can be on either FBD ④ or FBD ⑤; why?!!

In FBD ④,

$+\circlearrowright \sum M_D = 0 \Rightarrow -B_y(0.8) + 180(0.4) = 0$

$\Rightarrow \boxed{B_y = 90N\uparrow}$

$+\uparrow \sum F_y = 0 \Rightarrow 90 - 180 - 120 + E_y = 0 \Rightarrow E_y = 210N$

In FBD ⑤,

$+\circlearrowright \sum M_C = 0 \Rightarrow -240(0.4) - 210(0.8) + E_y(0.3) = 0$

$\Rightarrow E_y = 880N$

$\overset{+}{\rightarrow} \sum F_x = 0 \Rightarrow C_x - E_x = 0 \Rightarrow \boxed{C_x = 880N \rightarrow}$

$+\uparrow \sum F_y = 0 \Rightarrow C_y - 240 - 210 = 0 \Rightarrow \boxed{C_y = 450N\uparrow}$

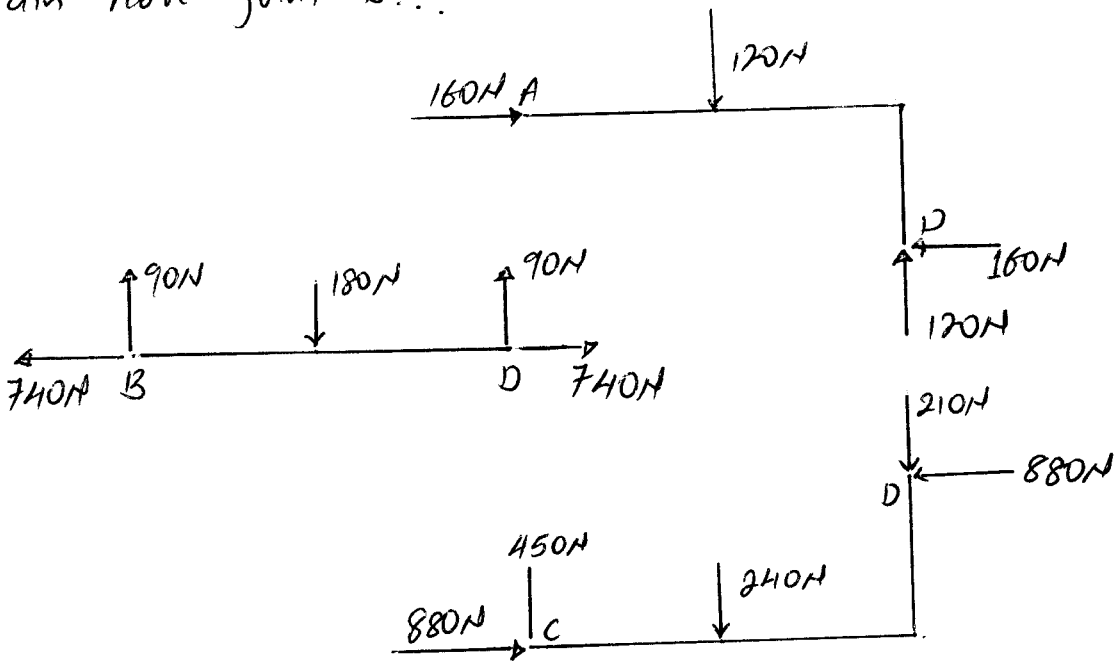
Back to FBD ④,

$\pm\rightarrow \Sigma F_x = 0 \Rightarrow B_x - 300 + 880 + 160 = 0$

$\Rightarrow \boxed{B_x = -740\,N = 740\,N \leftarrow}$

The solution is summarized in the FBD drawn.

Again note joint D!!!



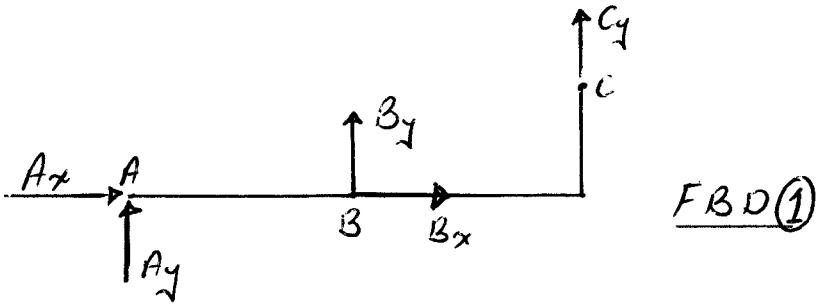
Problem 2

Given: The frame in Figure P2, in the question sheet.

Required: The forces on member ABC.

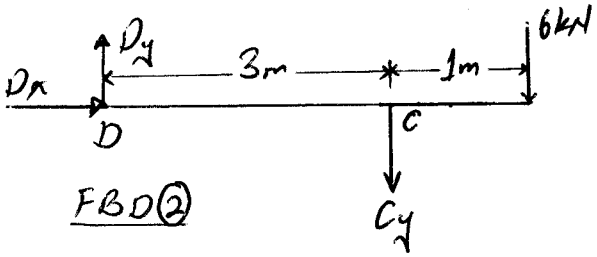
Solution.

First, the FBD of this member is drawn.



FBD (1)

Note that in FBD (1) (ABC) has 5 unknowns (and only 3 equations)



FBD (2)

In FBD (2) (DC)

$+\circlearrowleft \sum M_D = 0 \Rightarrow$

$\Rightarrow -(3)C_y - (4)6 = 0$

$\Rightarrow C_y = -8\,kN$

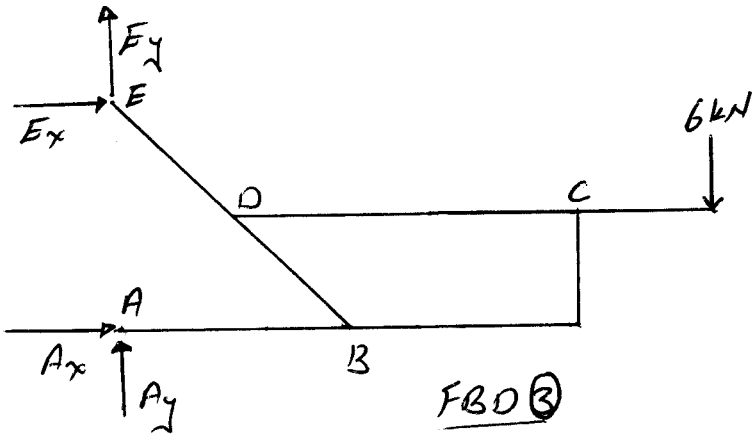
$= 8\,kN \uparrow$

Thus in FBD (1) (ABC), $\boxed{C_y = -8\,kN = 8\,kN \downarrow}$

$\pm \rightarrow \sum F_x = 0$ (FBD (2)) $\Rightarrow D_x = 0$

$+\uparrow \sum F_y = 0 \Rightarrow D_y = -2\,kN = 2\,kN \downarrow$

In FBD ③ (the complete structure)



FBD ③

$+\circlearrowright \Sigma M_E = 0 \Rightarrow$

$\Rightarrow -(5)6 + (2)A_x = 0$

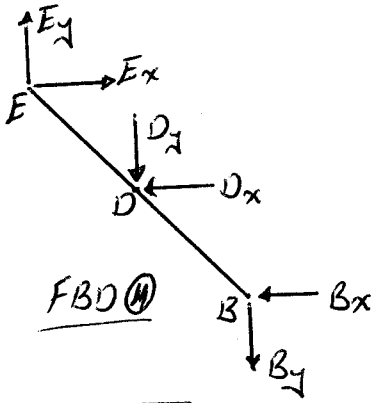
$\Rightarrow \boxed{A_x = 15\,kN \rightarrow}$

$\pm \rightarrow \Sigma F_x = 0 \Rightarrow$

$\Rightarrow E_x + 15 = 0$

$\Rightarrow E_x = -15\,kN = 15\,kN \leftarrow$

In FBD ④ (EDB),



FBD ④

$\pm \rightarrow \Sigma F_x = 0 \Rightarrow E_x - \cancel{D_x}^{\,0} - B_x = 0$

$\Rightarrow -15 - B_x = 0$

$\Rightarrow B_x = -15\,kN = 15\,kN \rightarrow$

Thus in FBD ① (ABC), $\boxed{B_x = -15\,kN = 15\,kN \leftarrow}$

In FBD ④,

$+\circlearrowright \Sigma M_E = 0 \Rightarrow -D_y(1) - B_y(2) - B_x(2) = 0$

$\Rightarrow (2)(1) - B_y(2) + (15)(2) = 0$

$\Rightarrow -2B_y + 32 = 0$

$\Rightarrow B_y = 16\,kN$

Thus $\boxed{B_y = 16\,kN \uparrow}$ in ABC

In FBD ① (ABC),

$+\uparrow \Sigma F_y = 0 \Rightarrow A_y + 16 - 8 = 0 \Rightarrow \boxed{A_y = -8\,kN = 8\,kN \downarrow}$

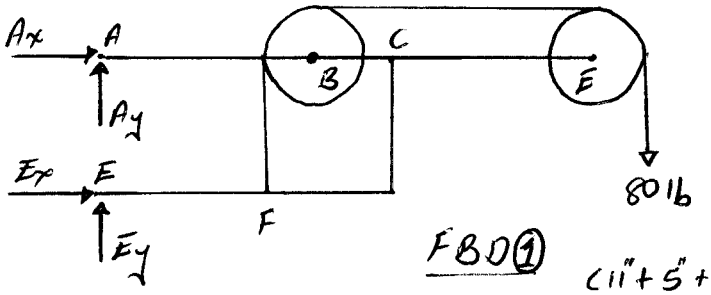
Problem 3

Given: Figure P3 in question sheet.

Required: Forces on member ABCD in the frame.

Solution:

First, FBD ① (the complete structure) is drawn.

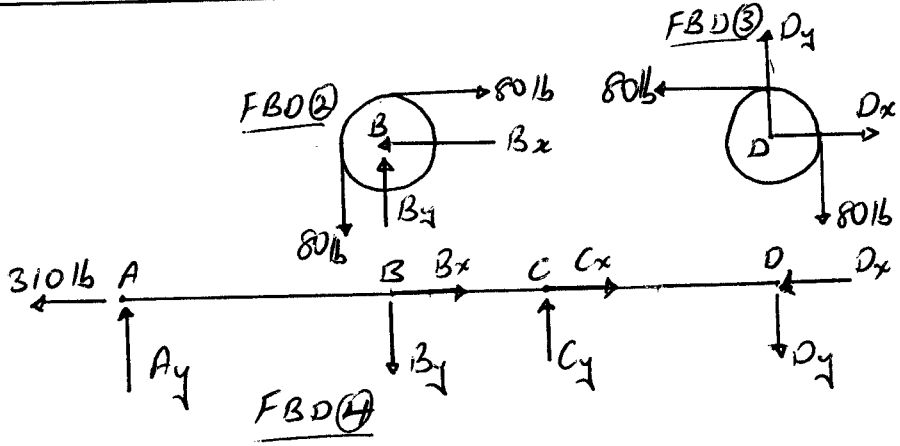


FBD ① (11" + 5" + 12" + 3" = 31")

In FBD ①,

$+\circlearrowleft \sum M_E = 0 \Rightarrow -(8)A_x - (31)80 = 0$

$\Rightarrow \boxed{A_x = -3101b = 3101b \leftarrow}$



From FBD ② of pulley at B,

$\pm \sum F_x = 0 \Rightarrow B_x = 80lb \leftarrow$

$+\uparrow \sum F_y = 0 \Rightarrow B_y = 80lb \uparrow$

Thus in FBD ④ (ABCD) from the results above; equal and opposite forces

$\boxed{B_x = 80lb \rightarrow}$ and $\boxed{B_y = 80lb \downarrow}$

From FBD ③ of pulley at D,

$\pm\rightarrow \Sigma F_x = 0 \Rightarrow D_x = 80\,lb \rightarrow$

$+\uparrow \Sigma F_y = 0 \Rightarrow D_y = 80\,lb \uparrow$

Thus in FBD ④ from the results above, (equal and opposite forces)

$\boxed{D_x = 80\,lb \leftarrow}$ $\boxed{D_y = 80\,lb \downarrow}$

In FBD ④ (ABCD),

$+\circlearrowleft \Sigma M_C = 0 \Rightarrow -A_y(16) + 80(5) - 80(12) = 0$

$\Rightarrow -16A_y - 560 = 0$

$\Rightarrow \boxed{A_y = -35\,lb = 35\,lb \downarrow}$

$+\uparrow \Sigma F_y = 0 \Rightarrow -35 - 80 + C_y - 80 = 0$

$\Rightarrow \boxed{C_y = 195\,lb \uparrow}$

$\pm\rightarrow \Sigma F_x = 0 \Rightarrow -310 + 80 + C_x - 80 = 0$

$\Rightarrow \boxed{C_x = 310\,lb \rightarrow}$

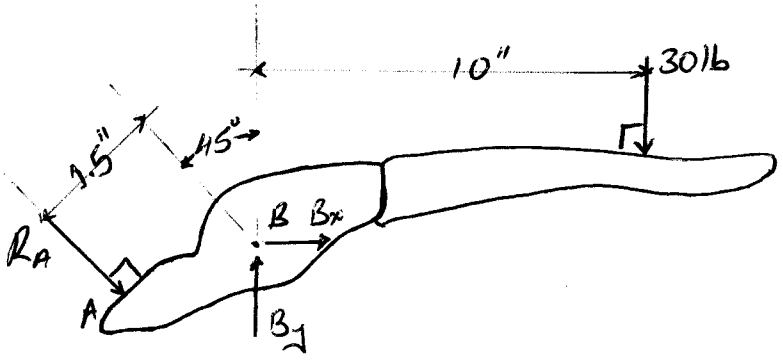
Problem 4

Given: Figure P4 as shown in the question sheet.

Required: Force exerted by the pliers on the bolt.

Solution

First, the FBD is drawn.



$$+\circlearrowleft \sum M_B = 0 \Rightarrow (R_A \times 1.5) - (30 \times 10) = 0$$

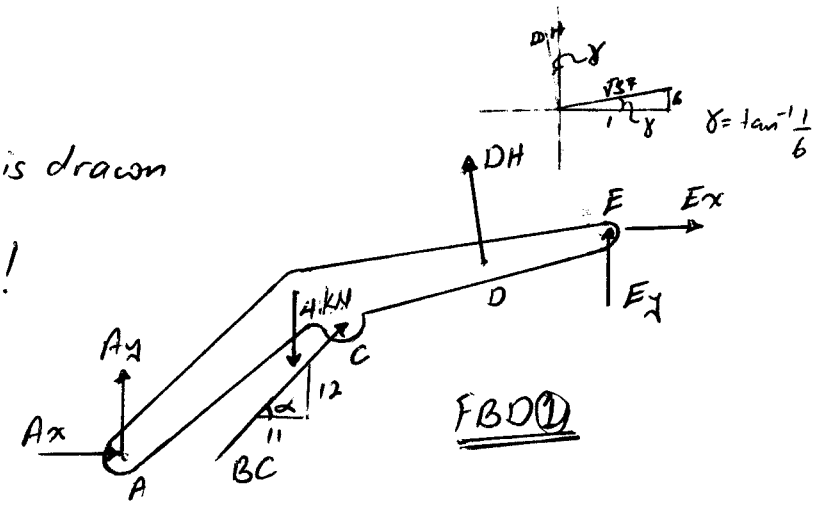
$$\Rightarrow \boxed{R_A = 200\,lb \searrow}$$

Problem 5

Given: Figure P5 as shown in the question sheet.

Required: Forces on member ACOE at points A and E

Solution.



First FBD① (ACOE) is drawn

6 unknowns ⇒ ??!!

$\tan\alpha = \frac{12}{11}$

$\alpha = 47.490^\circ$

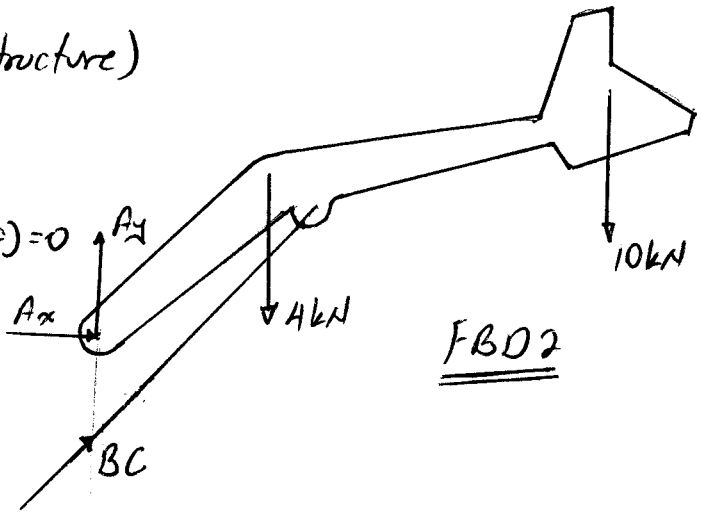
In FBD ② (the whole structure)

$+\circlearrowleft \Sigma M_A = 0 \Rightarrow$

$\Rightarrow BC\cos\alpha(6) - 4(8.5) - 10(28) = 0$

$\Rightarrow BC\cos 47.49(6) - 314 = 0$

$\Rightarrow BC = 77.448\ kN$



$\pm\rightarrow \Sigma F_x = 0 \Rightarrow$

$\Rightarrow A_x + BC\cos\alpha = 0 \Rightarrow \boxed{A_x = -52.33 = 52.33\ kN \leftarrow}$

$+\uparrow \Sigma F_y = 0 \Rightarrow A_y + BC\sin\alpha - 4 - 10 = 0$

$\Rightarrow \boxed{A_y = -43.09 = 43.09\ kN \downarrow}$

Back to FBD ①,

$+\circlearrowleft \Sigma M_E = 0 \Rightarrow A_x(10.5) - A_y(25) + 4(16.5) + BC\cos\alpha(4.5) - BC\sin\alpha(14) - DH\sqrt{37} = 0$

$\Rightarrow -52.33(10.5) + 43.09(25) + 77.448\cos 47.49(4.5) - 77.448\sin 47.49(14) - DH(\sqrt{37}) = 0$

$\Rightarrow DH = 4.93197\ kN$

$\pm \Sigma F_x = 0 \Rightarrow A_x + BC\cos\alpha - DH\sin\gamma + E_x = 0$

$\Rightarrow -52.33 + 77.448\cos 47.49 - 4.93197\sin 9.4623 + E_x = 0$

$\Rightarrow \boxed{E_x = -0.810\ kN = 0.810\ kN \leftarrow}$

$+\uparrow \Sigma F_y = 0 \Rightarrow A_y - 4 + BC\sin\alpha + DH\cos\gamma + E_y = 0$

$\Rightarrow -43.09 - 4 + 77.448\sin 47.49 + 4.932\cos 9.4623 + E_y = 0$

$\Rightarrow \boxed{E_y = -14.87\ kN = 14.87\ kN \downarrow}$