Christopher King

Mechanical Design 1

01 Assignment

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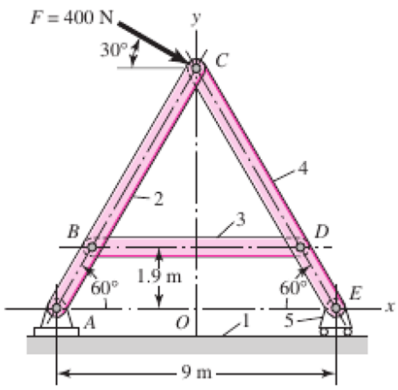
Mechanical Design 1

Class Section 01

09/09/2020

Problem 1

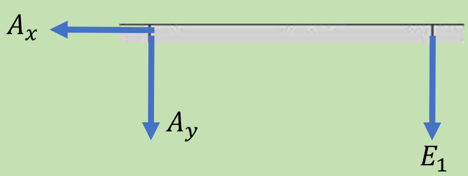
Sketch a free-body diagram of each element in the figure. Use the equations of equilibrium to compute the magnitude and direction of all the internal forces and reactions.



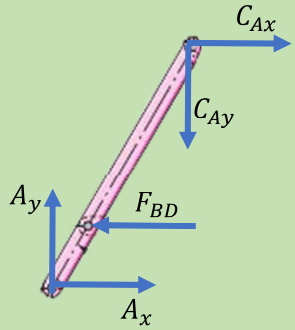
Solution:

For this question, we are asked to sketch a free-body diagram of each element in the figure. Use the equations of equilibrium to compute the magnitude and direction of all the internal forces and reactions.

1.



2.



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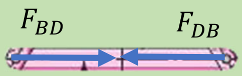

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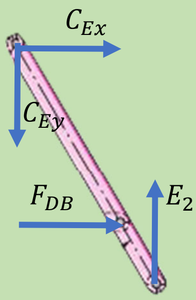
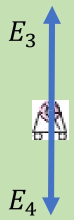


5.



From the free body diagram for the whole part, I can know that

$$\circlearrowleft \sum M_A = 0 \Longrightarrow 9E_1 - 9F = 0$$

$$\Longrightarrow E_1 = 400 \text{ N}$$

$$\uparrow \sum F_y = 0 \Longrightarrow A_y + E_1 - 200 \text{ N} = 0$$

$$\Longrightarrow A_y = -200 \text{ N} = 200 \text{ N} \downarrow$$

$$\longrightarrow \sum F_x = 0 \Longrightarrow A_x + 200\sqrt{3} \text{ N} = 0$$

$$\Longrightarrow A_x = -200\sqrt{3} \text{ N} = 200\sqrt{3} \text{ N} \leftarrow$$

From the free body diagram for the part 5, I can know that

$$E_3 = 400 \text{ N} \uparrow$$

$$E_4 = 400 \text{ N} \downarrow$$

From the free body diagram for the part 4, I can know that

$$E_2 = 400 \text{ N} \uparrow$$

$$\uparrow \sum F_y = 0 \Longrightarrow -C_{E1} + E_2 = 0$$

$$\Longrightarrow C_{E1} = 400 \text{ N} \downarrow$$

$$\circlearrowleft \sum M_C = 0 \Longrightarrow 4.5E_2 + \left(4.5\sqrt{3} - 1.9\right)F_{DB} = 0$$

$$\Longrightarrow F_{DB} = -305.38 \text{ N} = 305.38 \text{ N} \leftarrow$$

$$\rightarrow \sum F_x = 0 \Longrightarrow F_{DB} + C_{Ex} = 0$$

$$\Longrightarrow C_{Ex} = 305.38 \text{ N} \rightarrow$$

From the free body diagram for the part 3, I can know that

$$\rightarrow \sum F_x = 0 \Longrightarrow F_{BD} - F_{DB} = 0$$

$$F_{BD} = -305.38 \text{ N} = 305.38 \text{ N} \leftarrow$$

From the free body diagram for the part 2, I can know that

$$\uparrow \sum F_y = 0 \Longrightarrow A_y - C_{Ay} = 0$$

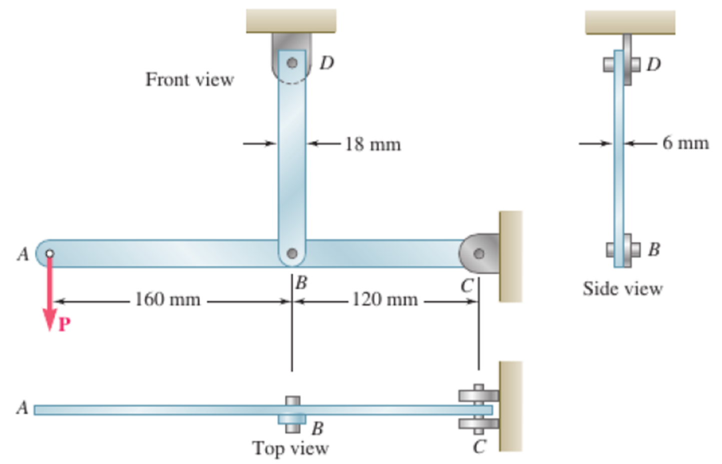
$$\Longrightarrow C_{Ay} = -200 \text{ N} = 200 \text{ N} \uparrow$$

$$\rightarrow \sum F_x = 0 \Longrightarrow C_{Ax} + A_x - F_{BD} = 0$$

$$\Longrightarrow C_{Ax} = 41.03 \text{ N} \rightarrow$$

Problem 2

In the steel structure shown, a 6-mm-diameter pin is used at *C* and 10-mm-diameter pins are used at *B* and *D*. The ultimate shearing stress is 150 MPa at all connections, and the ultimate normal stress is 400 MPa in link *BD*. Knowing that a factor of safety of 3.0 is desired, determine the largest load *P* that can be applied at *A*.



Solution:

For this question, we are asked to determine the largest load P that can be applied at A.

From the free body diagram for the whole part, I can know that

$$\circlearrowleft \sum M_C = 0 \Longrightarrow 280P - 120F_{BD} = 0$$

$$\Longrightarrow F_{BD} = \frac{7}{3}P$$

$$\circlearrowleft \sum M_B = 0 \Longrightarrow 160P - 120F_C = 0$$

$$\Longrightarrow F_C = \frac{4}{3}P$$

From the question, I can know that

$$\frac{F_{BD}}{(6\ \text{mm})(18\ \text{mm})} \leq \frac{400\ \text{MPa}}{3.0}$$

$$\frac{\frac{7}{3}P}{(6\ \text{mm})(18\ \text{mm})} \leq \frac{400\ \text{MPa}}{3.0}$$

$$P \leq 6.17\ \text{kN}$$

$$\frac{F_C}{\frac{\pi}{4}(6\text{ mm})^2 \times 2} \le \frac{150\text{ MPa}}{3.0}$$

$$\frac{\frac{4}{3}P}{\frac{\pi}{4}(6\text{ mm})^2 \times 2} \le \frac{150\text{ MPa}}{3.0}$$

$$P \le 2.121\text{ kN}$$

$$\frac{F_{BD}}{\frac{\pi}{4}(10\text{ mm})^2} \le \frac{150\text{ MPa}}{3.0}$$

$$\frac{\frac{7}{3}P}{\frac{\pi}{4}(10\text{ mm})^2} \le \frac{150\text{ MPa}}{3.0}$$

$$P \le 1.683\text{ kN}$$

Therefore, the largest load P that can be applied at A is equal to 1.683 kN.

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