

Sec.2

EGM 3520 Mechanics of Materials (MoM)

Beer et al. 2012, Mechanics of Materials, McGraw-Hill.

P1.14, p.23

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- 1.14** A couple \mathbf{M} of magnitude $1500 \text{ N} \cdot \text{m}$ is applied to the crank of an engine. For the position shown, determine (a) the force \mathbf{P} required to hold the engine system in equilibrium, (b) the average normal stress in the connecting rod BC , which has a 450-mm^2 uniform cross section.

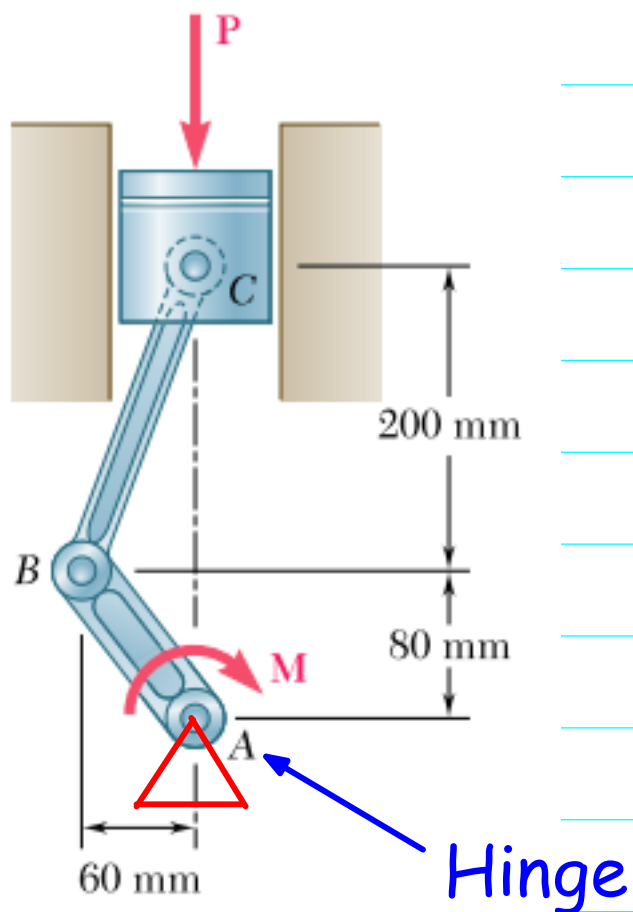


Fig. P1.14

Pause video NOW !

Work out the next step

→ individually first

→ discuss with teammates
if you get stuck

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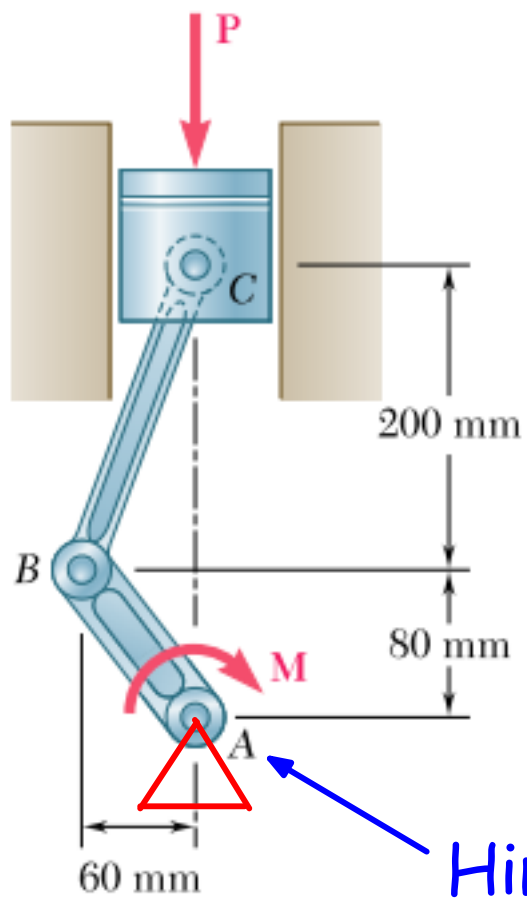
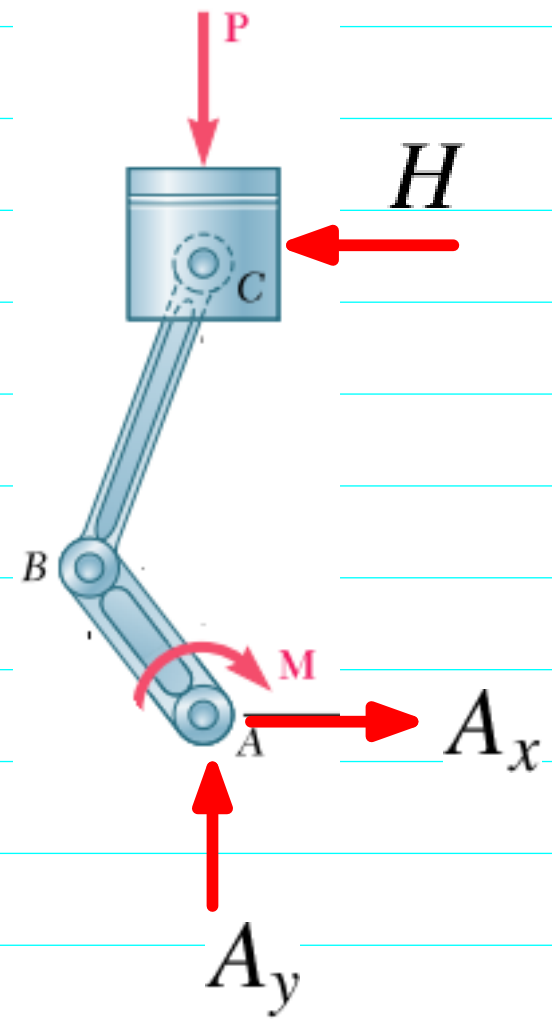
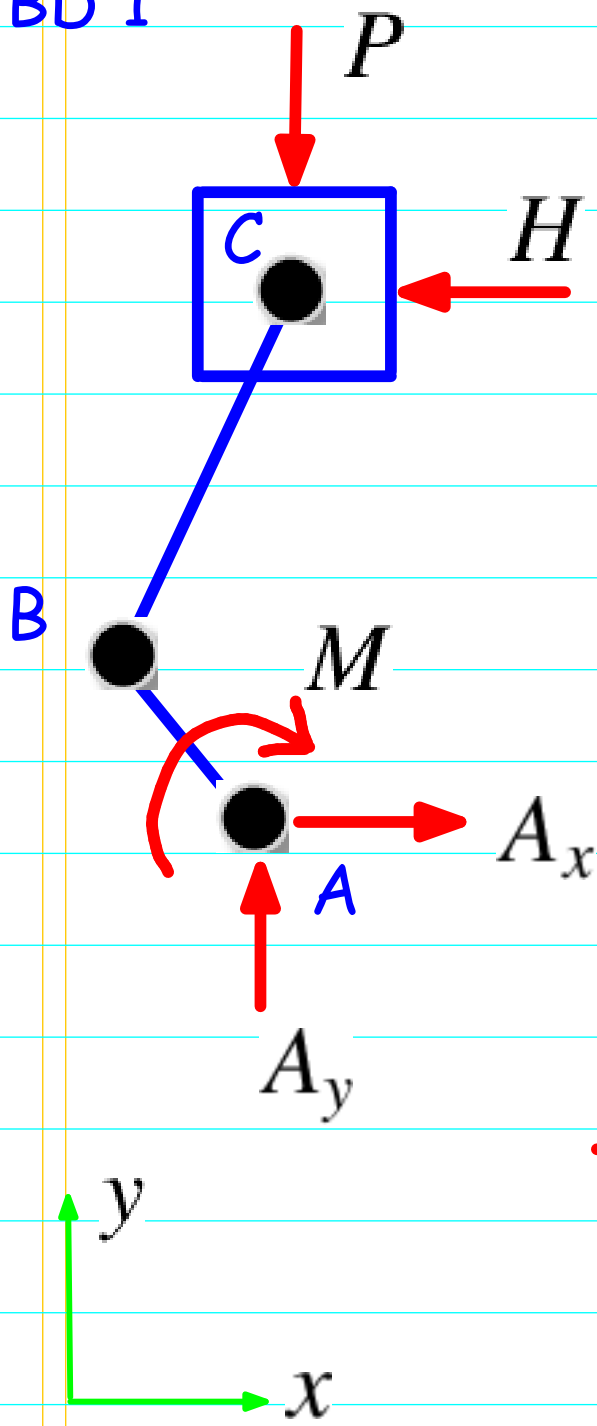


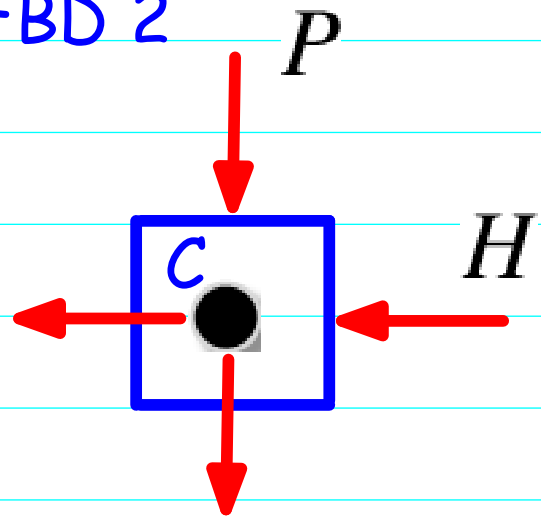
Fig. P1.14



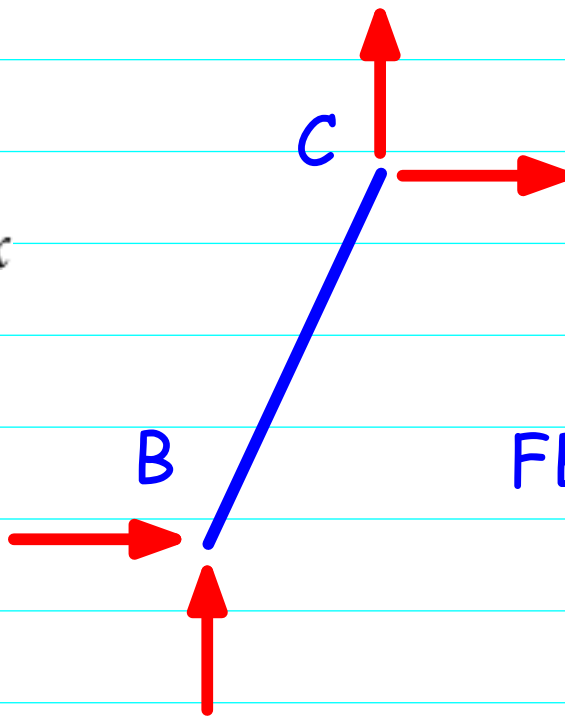
FBD 1



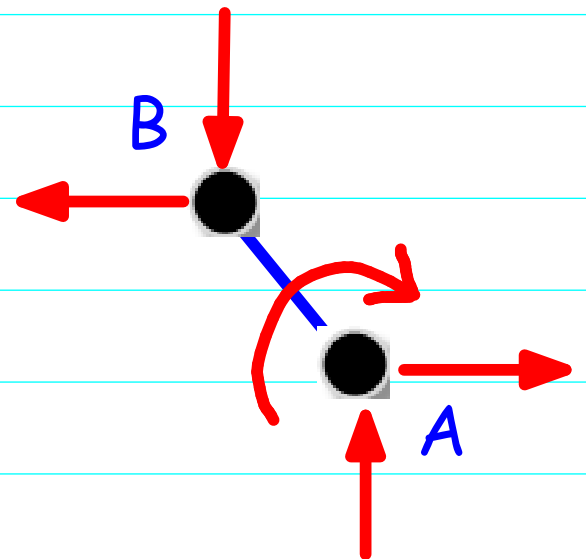
FBD 2

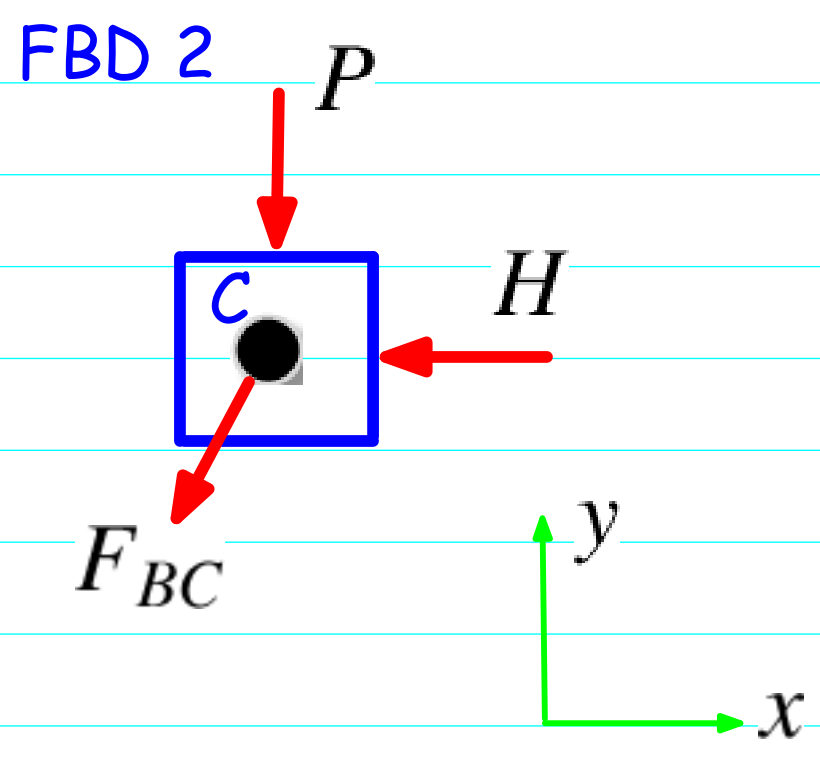
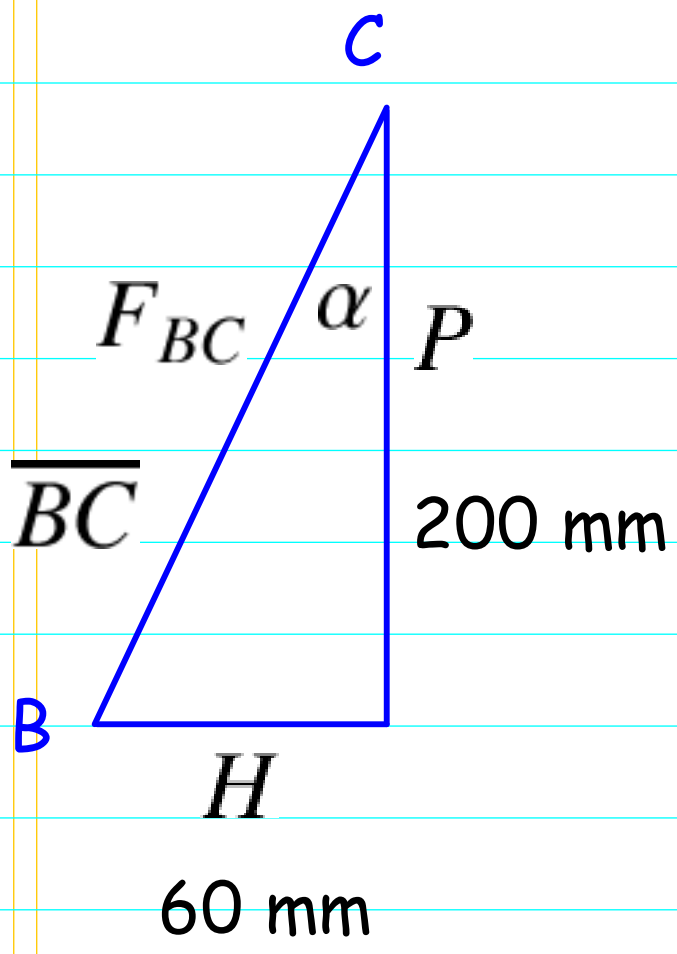
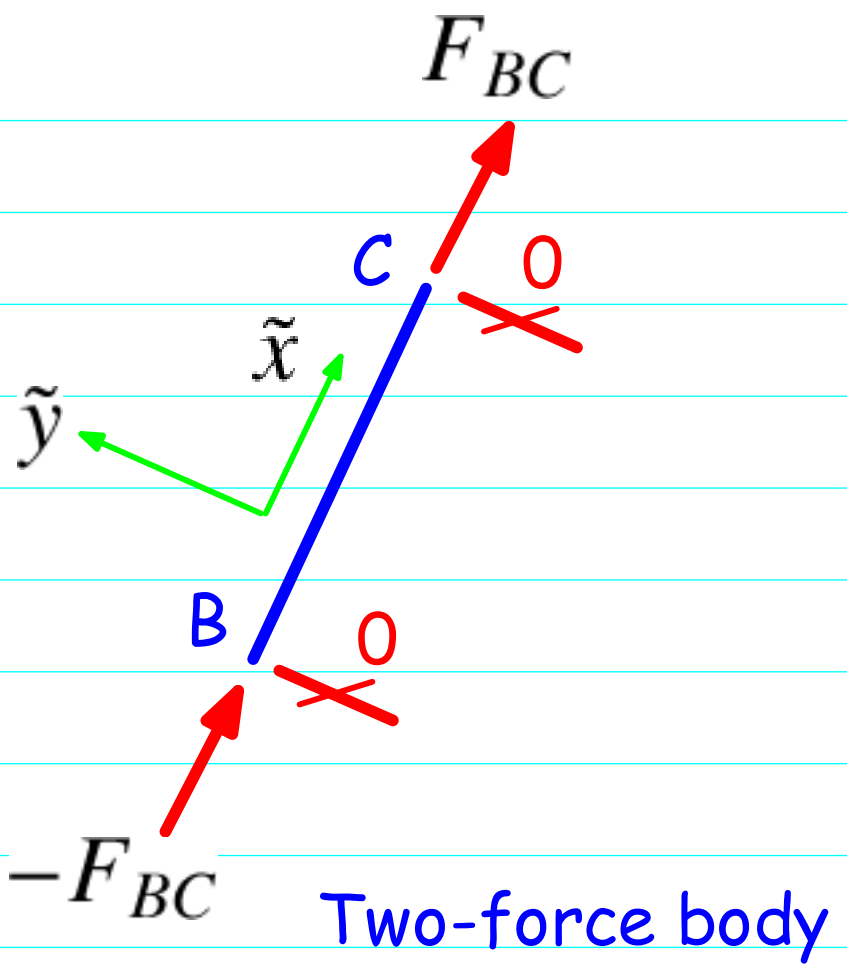
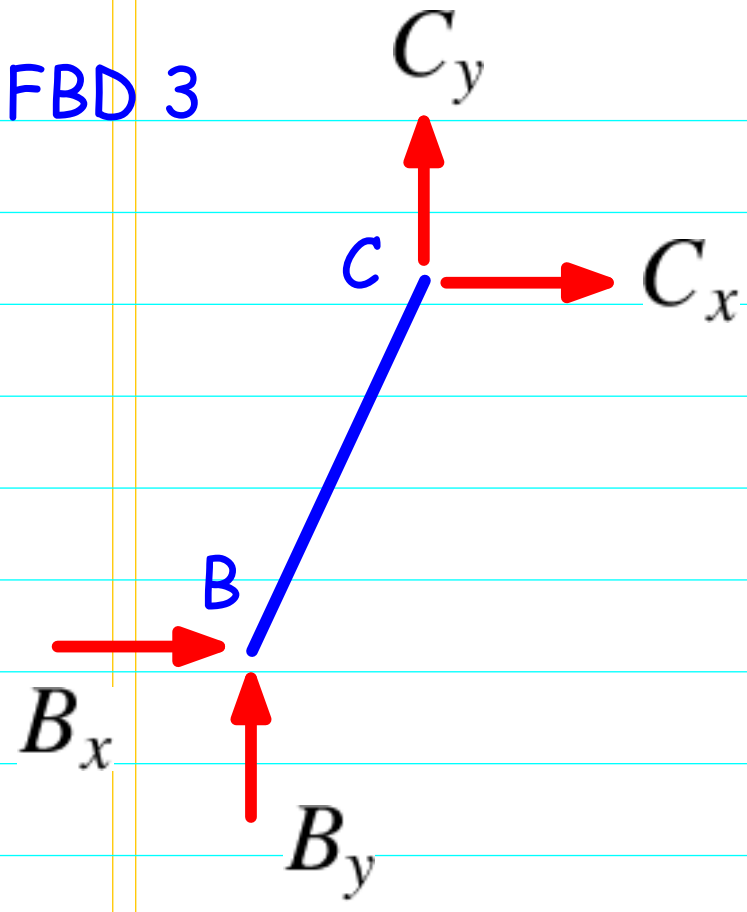


FBD 3



FBD 4





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FBD 1

$$\sum M_A = 0 : 0.280 \text{ m } H - 1,500 \text{ N.m} = 0 \quad (1)$$

$$\sum M_A = 0 : 0.280 \text{ m } H - 1,500 \text{ N.m} = 0$$

$$H = 5.3571 \times 10^3 \text{ N} \quad (2)$$

$$H = 5.3571 \times 10^3 \text{ N}$$

Method 1: Similar triangles Why ?

$$\frac{P}{H} = \frac{200}{60} \Rightarrow P = 17.86 \times 10^3 \text{ N} \quad (3)$$

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$$\overline{BC} = \sqrt{200^2 + 60^2} = 208.81 \text{ mm} \quad (4)$$

$$\overline{BC} = \sqrt{200^2 + 60^2} = 208.81 \text{ mm}$$

$$\frac{F_{BC}}{H} = \frac{208.81}{60} \Rightarrow F_{BC} = 18.643 \times 10^3 \text{ N} \quad (5)$$

$$\frac{F_{BC}}{H} = \frac{208.81}{60} \Rightarrow F_{BC} = 18.643 \times 10^3 \text{ N}$$

Problem: What is the sign of F_{BC} ? Negative for equilibrium, i.e.,

$$F_{BC} = -18.643 \times 10^3 \text{ N} \quad (6)$$

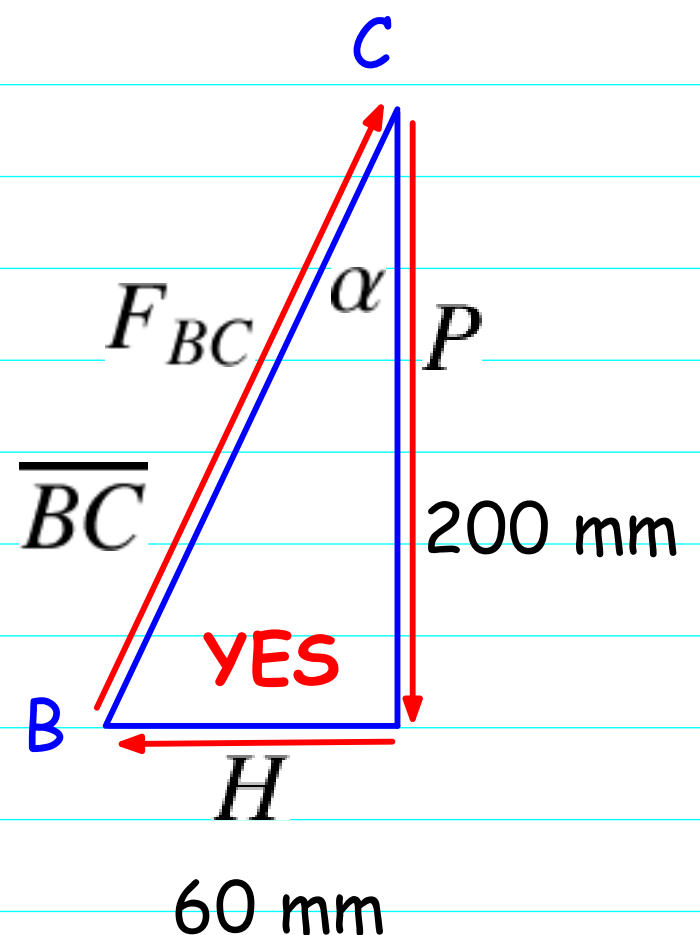
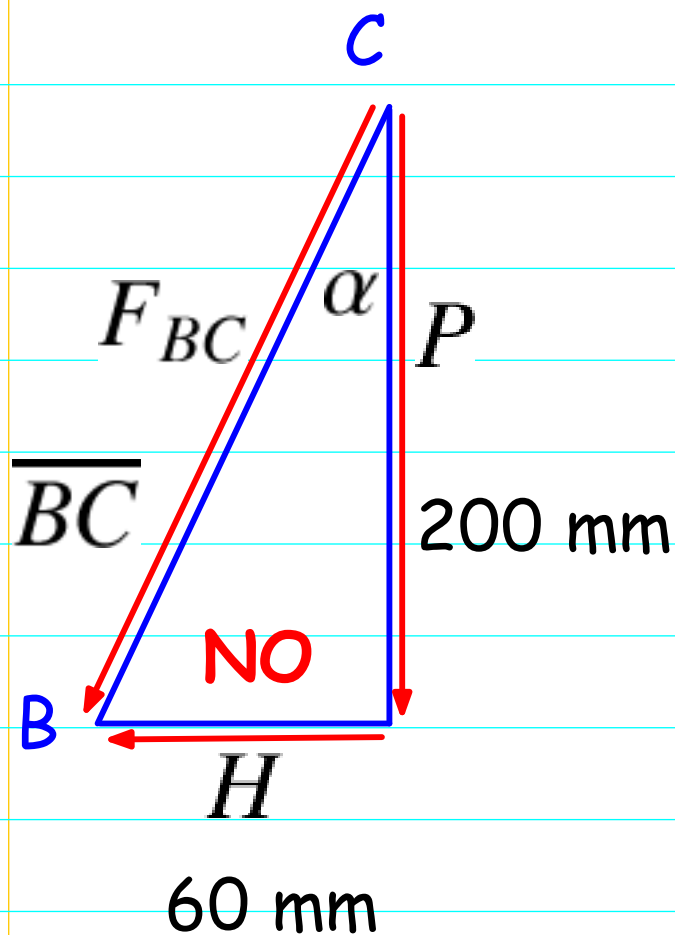
$$F_{BC} = -18.643 \times 10^3 \text{ N}$$

Why ?

Because when adding the directions, the triangle of vectors as on p.1p-3 does not satisfy equilibrium, i.e., sum of forces equal zero:

$$\sum \mathbf{F}_i = \mathbf{0} \text{ or } \sum \vec{F}_i = \vec{0} \quad (1)$$

$$\sum \mathbf{F}_i = \mathbf{0} \text{ or } \sum \vec{F}_i = \vec{0}$$



$$\vec{P} + \vec{H} = \vec{F}_{BC} \quad (2) \quad \vec{P} + \vec{H} = -\vec{F}_{BC}$$

$$\vec{P} + \vec{H} = \vec{F}_{BC}$$

$$\vec{P} + \vec{H} + \vec{F}_{BC} = \vec{0} \quad (3)$$

$$\vec{P} + \vec{H} + \vec{F}_{BC} = \vec{0}$$

The above method is also restricted to the case with 3 forces applying on a rigid body.

Method 2: Vector equations of equilibrium

Recommended

FBD 2, p.1p-2, (1) p.1p-5, and figs on p.1p-5 (angle):

$$\vec{P} + \vec{H} + \vec{F}_{BC} = \vec{0}$$

$$\vec{P} + \vec{H} + \vec{F}_{BC} = \vec{0} \quad (1)$$

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x-components:

$$0 - H - F_{BC} \sin \alpha = 0 \Rightarrow F_{BC} = -H / \sin \alpha \quad (1)$$

$$0 - H - F_{BC} \sin \alpha = 0 \Rightarrow F_{BC} = -H / \sin \alpha$$

$$\sin \alpha = \frac{60}{208.81} \quad (2)$$

$$\sin \alpha = \frac{60}{208.81}$$

$$F_{BC} = -18.643 \times 10^3 \text{ N} \quad (6) \text{ p.2-4}$$

$$F_{BC} = -18.643 \times 10^3 \text{ N}$$

y-components: HW

Average normal stress in BC: HW