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 **M** of magnitude 1500 N · m is applied to the crank of an engine. For the position shown, determine (*a*) the force **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.

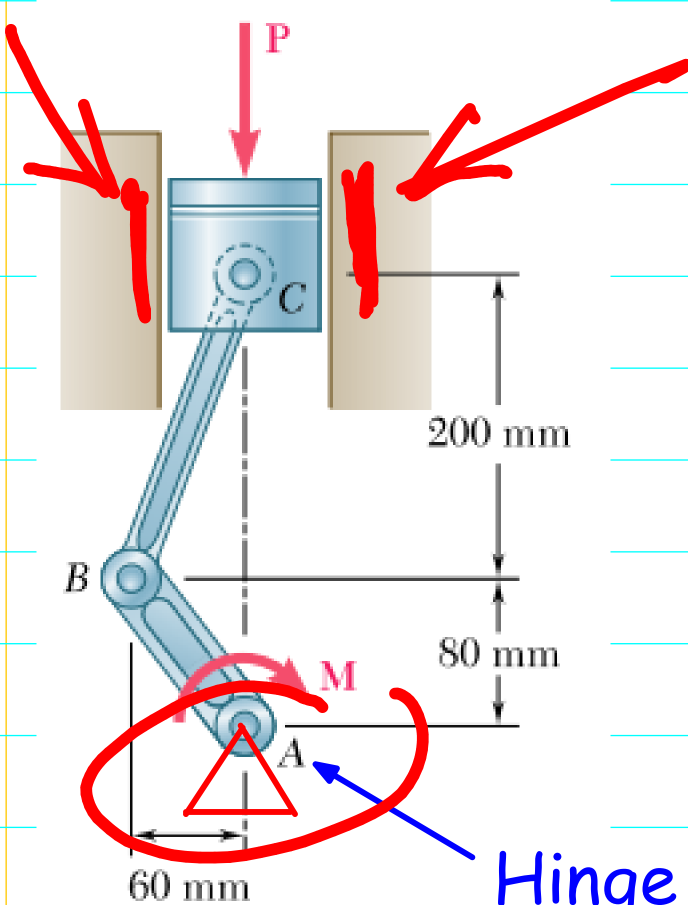


Fig. P1.14

Pause video NOW !

Work out the next step

→ individually first

→ discuss with teammates

if you get stuck

then continue to watch the video

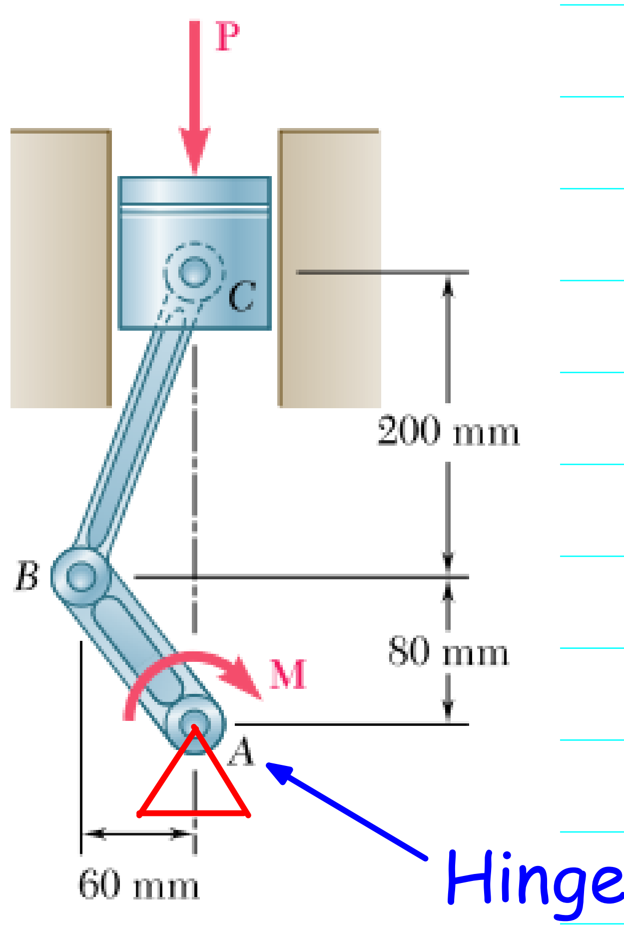
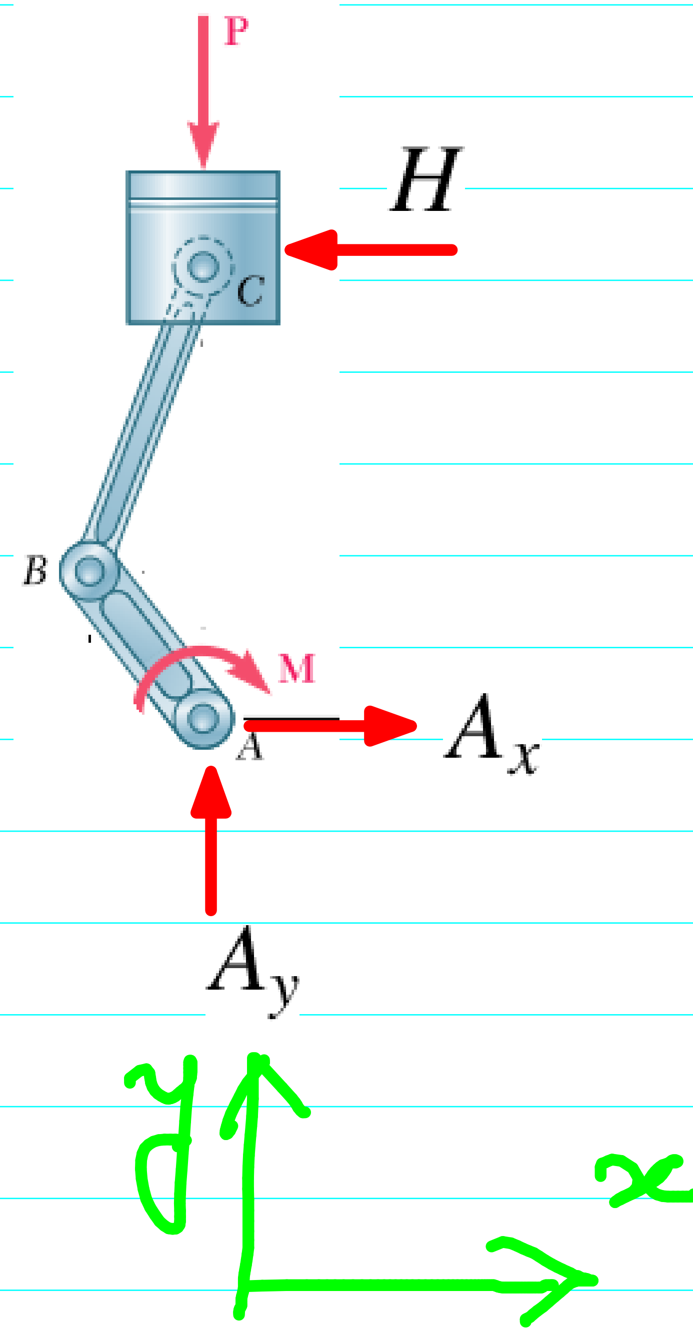
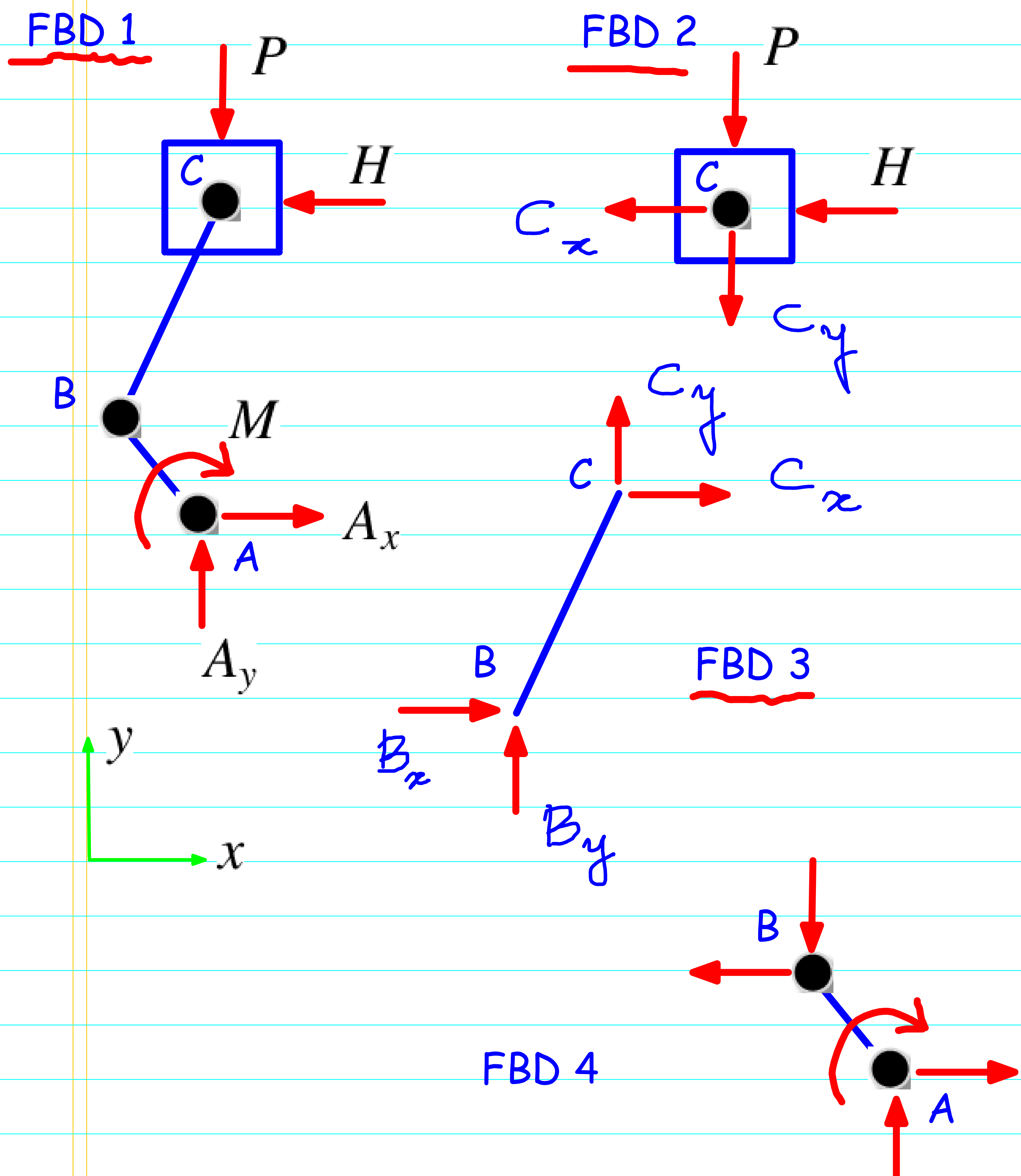


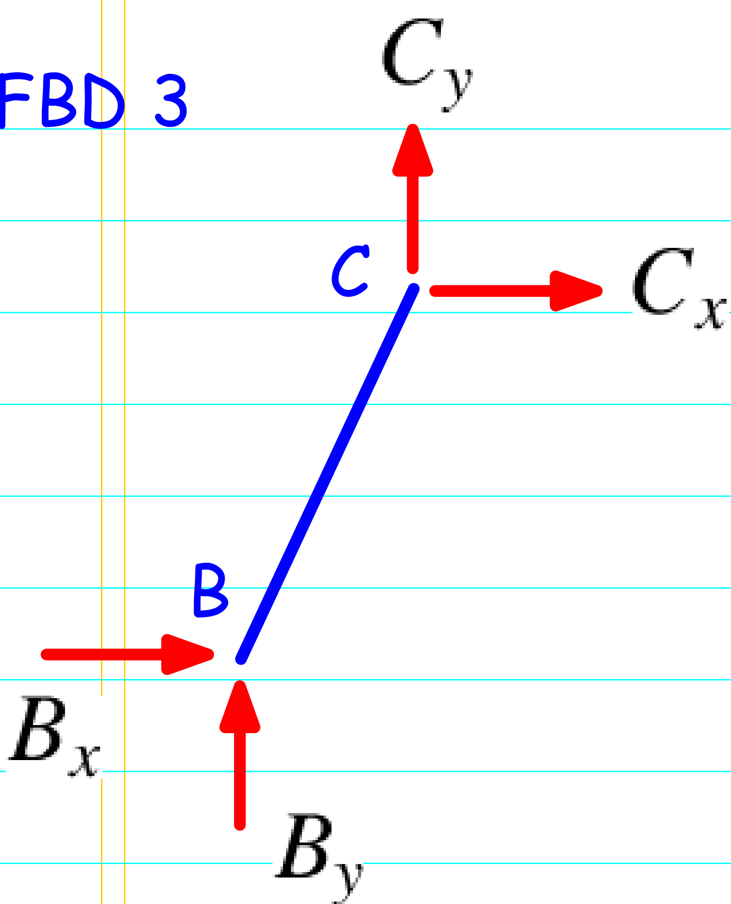
Fig. P1.14

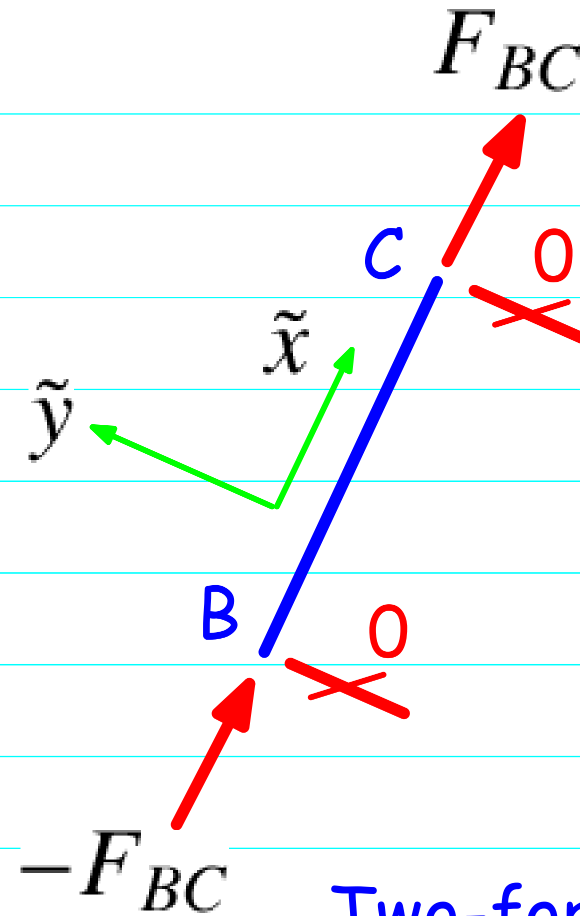




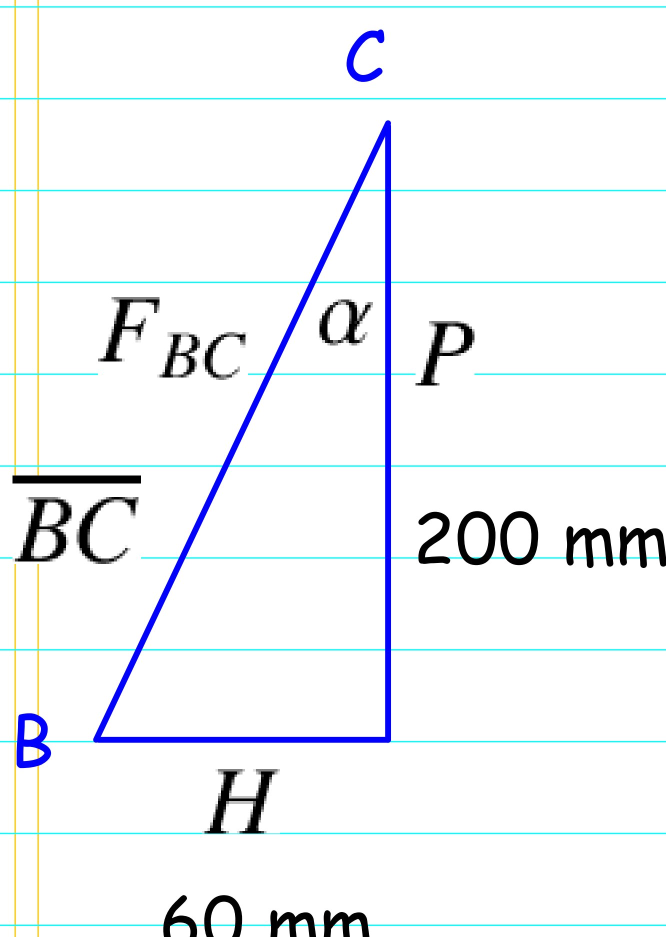
FBD 1
P
C
H
B
M
A
Ax
Ay
y
x
FBD 2
P
C
H
Cx
Cy
FBD 3
Cy
C
Cx
B
Bx
By
FBD 4
B
A

FBD 3

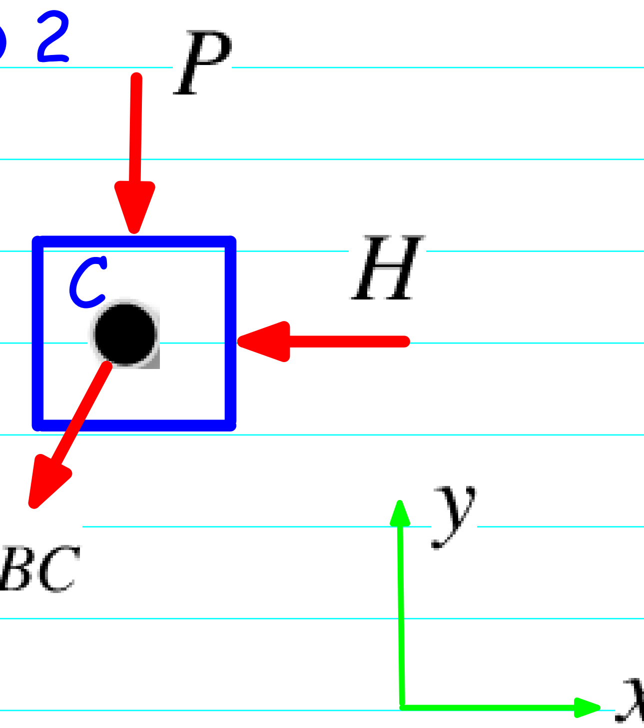




Two-force body



FBD 2



FBD 1

$$\sum M_A = 0 : 0.280\, m\ H - 1,500\, N.m = 0 \qquad (1)$$

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$$H = 5.3571 \times 10^3\, N \qquad (2)$$

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Method 1: Similar triangles Why ?

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

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

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

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

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

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

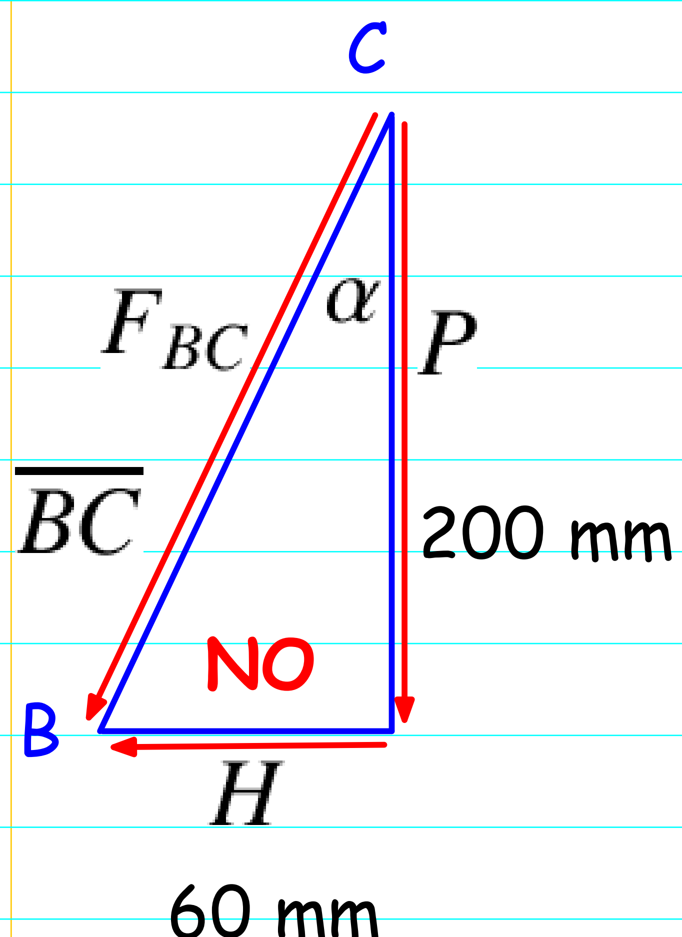
F_{BC} = - 18.643 \times 10^3 \, N

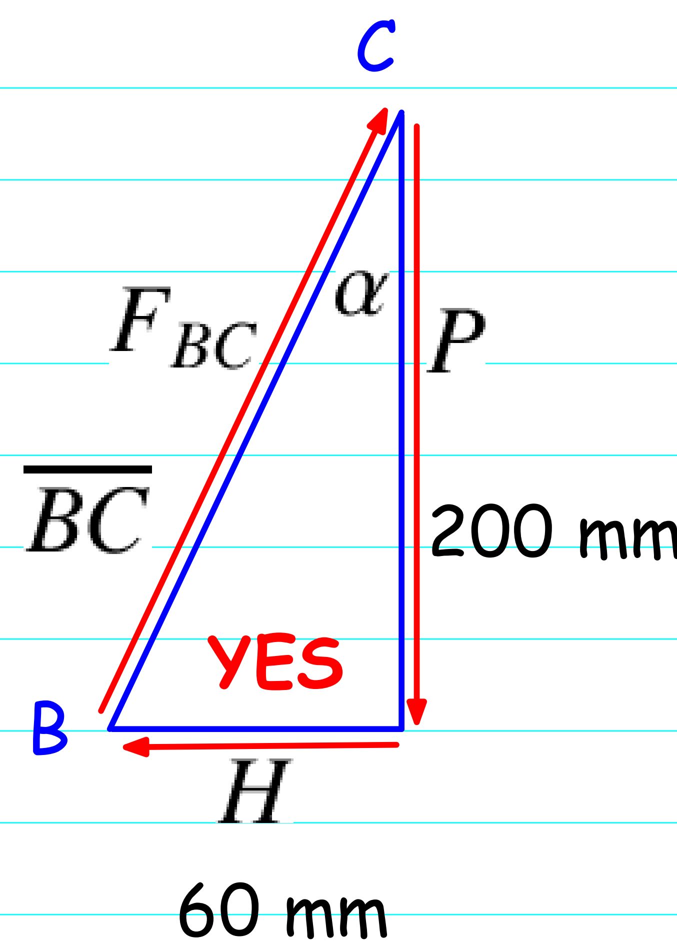
Why ?

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:

$$\sum \mathbf{F}_i = \mathbf{0} \ \text{ or } \sum \overrightarrow{F}_i = \overrightarrow{0} \qquad (1)$$

\sum \mathbf F_i = \mathbf 0 \ \text{ or } \sum \overrightarrow F_i = \overrightarrow 0





$$\overrightarrow{P} + \overrightarrow{H} = \overrightarrow{F}_{BC} \qquad (2)$$

\overrightarrow P + \overrightarrow H = \overrightarrow F_{BC}

$$\overrightarrow{P} + \overrightarrow{H} = -\overrightarrow{F}_{BC}$$

$$\overrightarrow{P} + \overrightarrow{H} + \overrightarrow{F}_{BC} = \overrightarrow{0} \qquad (3)$$

\overrightarrow P + \overrightarrow H + \overrightarrow F_{BC} = \overrightarrow 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):

$$\overrightarrow P + \overrightarrow H + \overrightarrow F_{BC} = \overrightarrow 0 \qquad (1)$$

\overrightarrow P + \overrightarrow H + \overrightarrow F_{BC} = \overrightarrow 0

x-components:

$$0 - H - F_{BC} \sin \alpha = 0 \Rightarrow F_{BC} = -H / \sin \alpha \qquad (2)$$

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

$$\sin \alpha = \frac{60}{208.81} \qquad (3)$$

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

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

(6) p.2-4

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

y-components: HW

Average normal stress in BC: HW