



# MECH 223 - Solid Mechanics

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**20528- MECH 223 – L52 (09:00-10:15)**

**Monday, Wednesday**

**Prepared by:**

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**and**

**Dr. Samahat Samim (TA)**

# Equilibrium of Rigid Bodies

## Chapter 5

$$\sum F_x = 0 \quad \rightarrow +$$

$$\sum F_y = 0 \quad \uparrow +$$

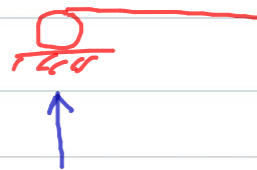
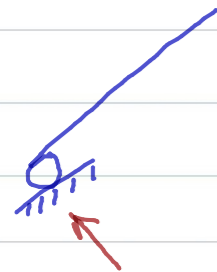
$$\sum M = 0 \quad \curvearrowright +$$

@ point

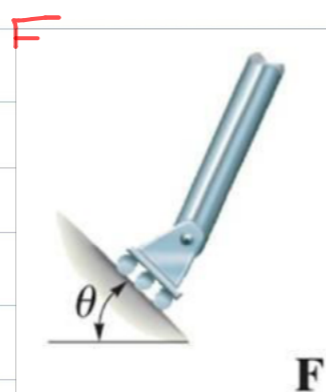
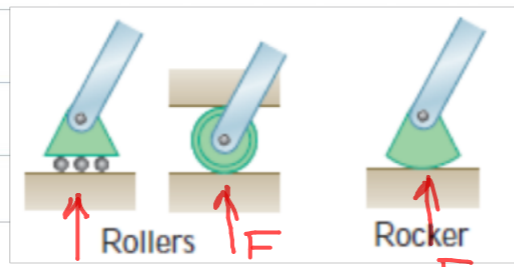
3-unknowns

Supports :-

① Roller :-

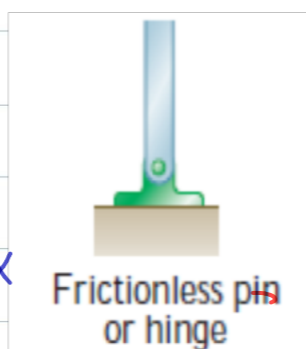
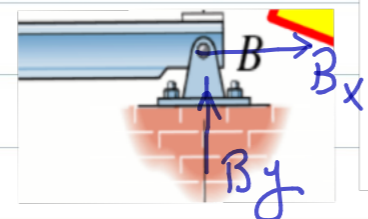


1-Reaction



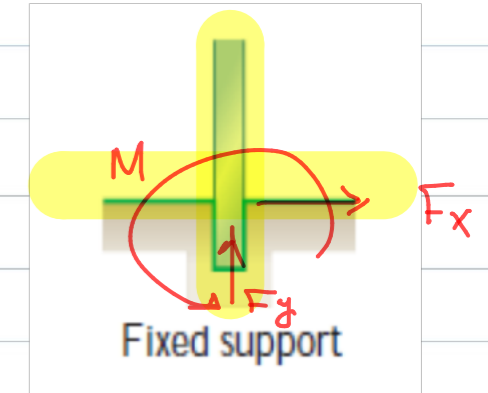
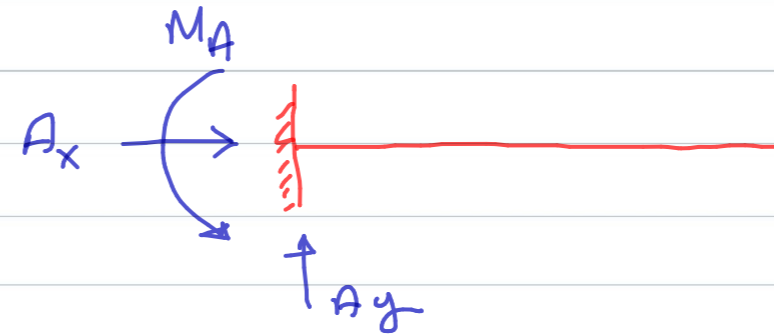
② Pin or hinge :-

2-Reaction



③ Fixed :-

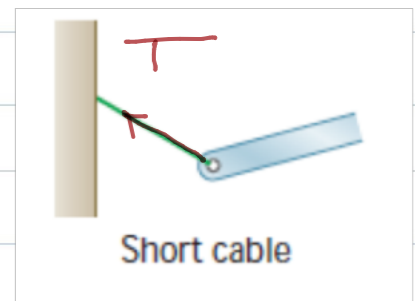
3-Reaction



④ Cable :-

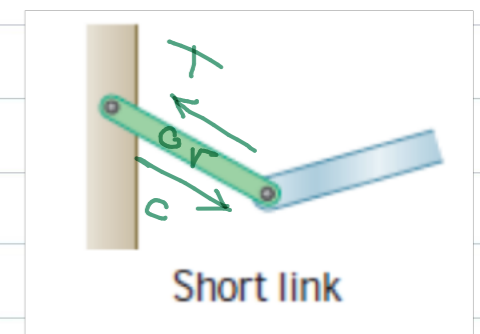
→ outside

Tension Force



⑤ Link

Compression (or) Tension



## Steps :-

1) FBD } Remove Surrounding  
External Forces  
Reactions (only 3)  
Dimensions

2) Resolve all inclined Forces in  $(x, y)$  direction

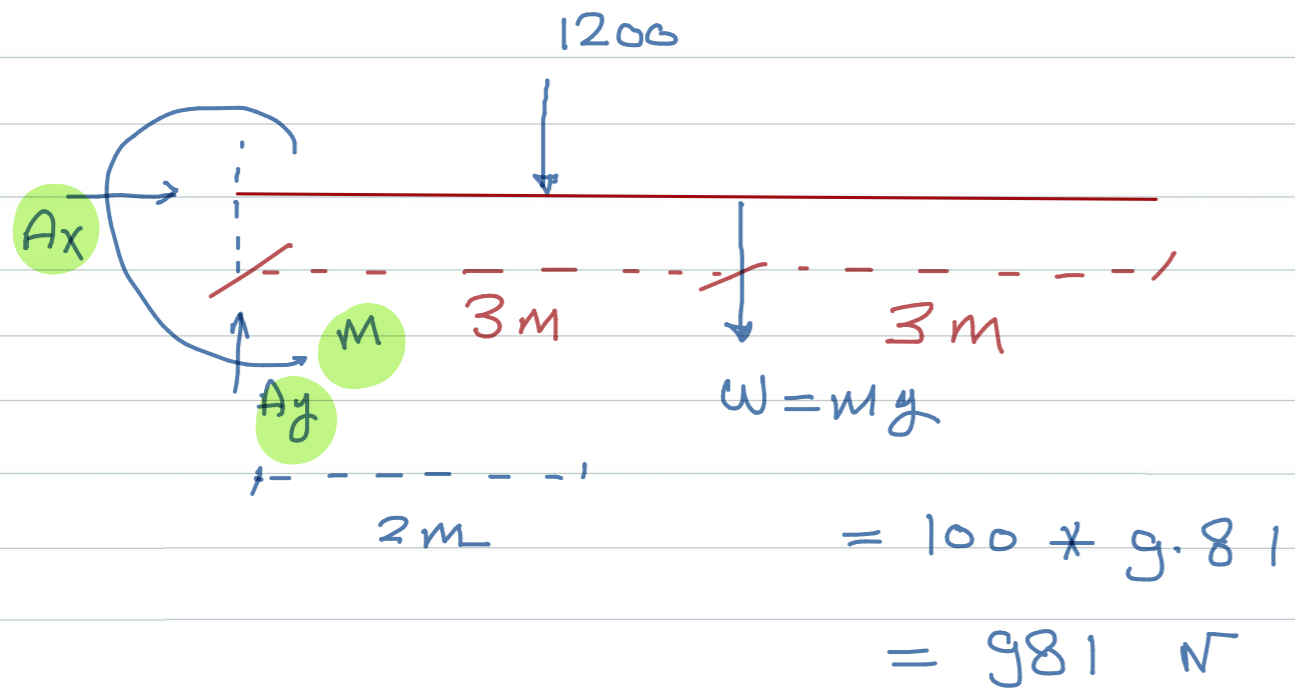
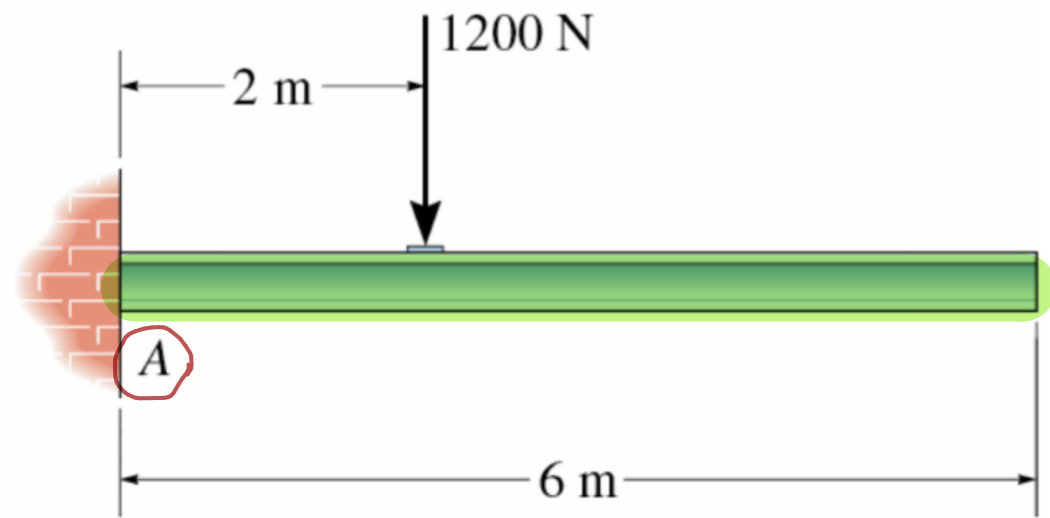
3)  $\sum M = 0$   $\curvearrowright +$   
@ Pin  
@ Fixed  
@ Point Contact  
two unknowns

4)  $\sum F_x = 0$   $\rightarrow +$

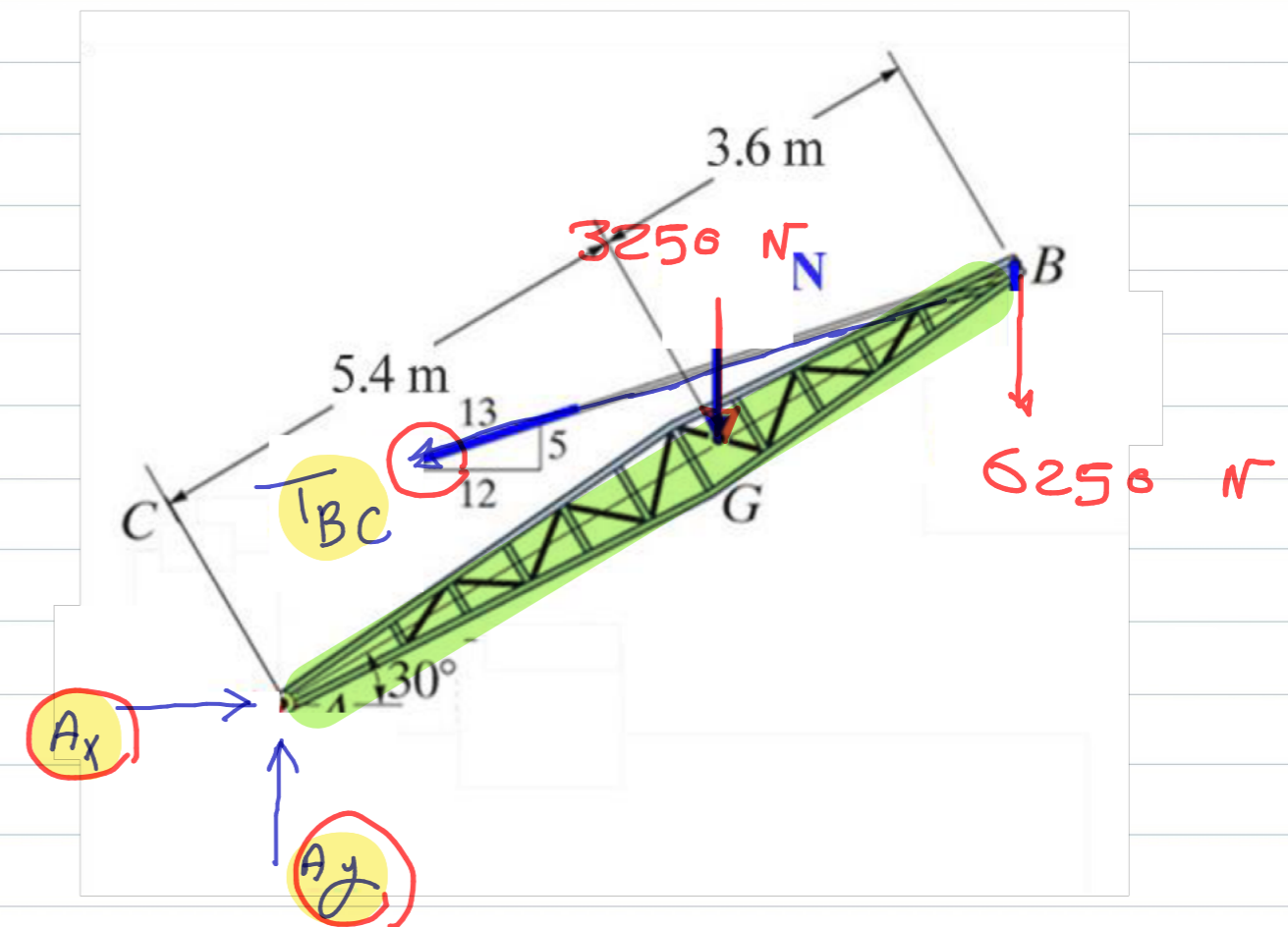
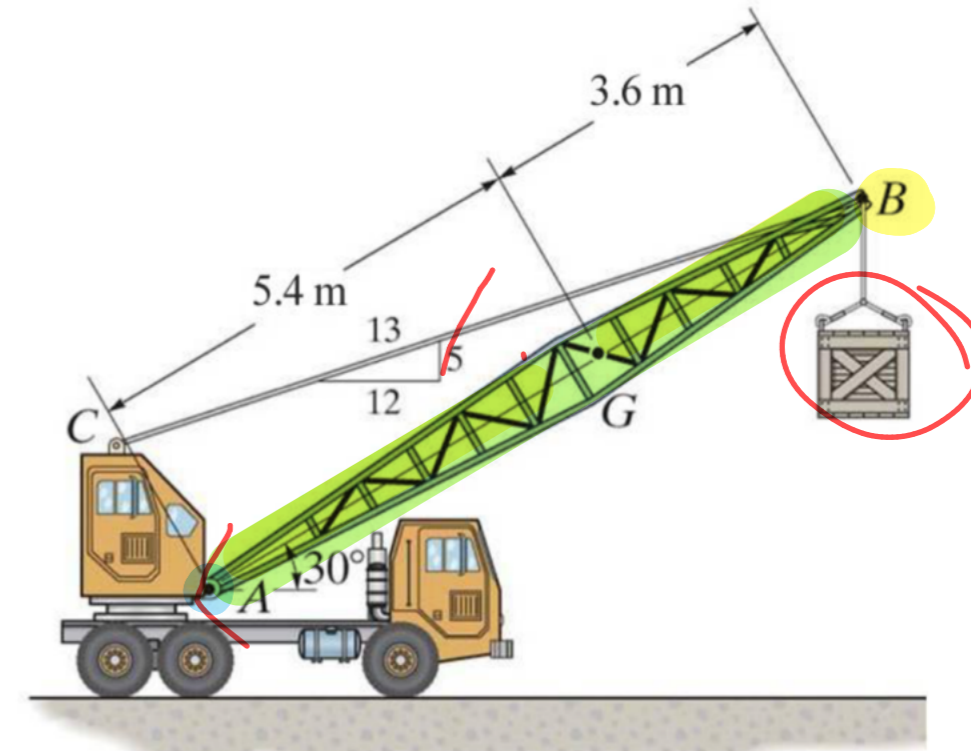
5)  $\sum F_y = 0$   $\uparrow +$

Weight @ Center

Draw the FBD of the uniform beam. The beam has a mass of 100kg.

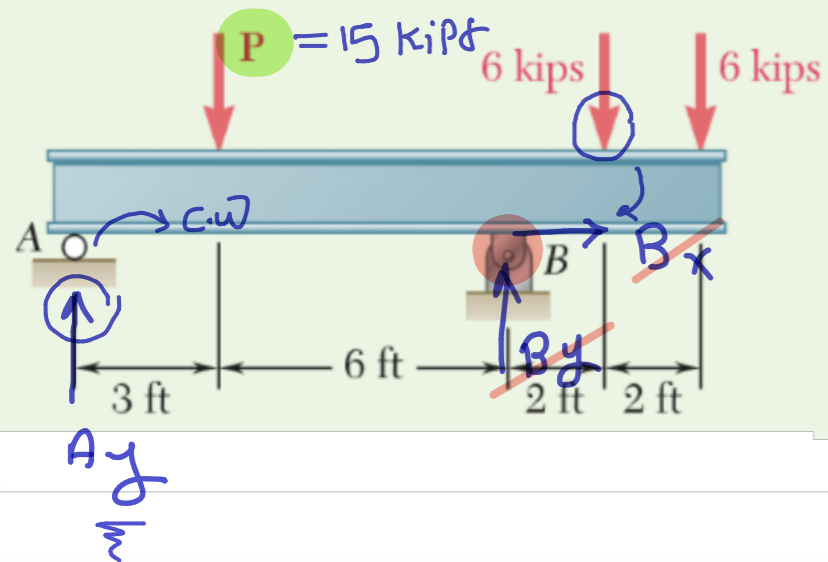


Draw the FBD of the crane boom, which is supported by a pin at A and cable BC. The load of 6250 N is suspended at B and the boom weighs 3250 N.



## Sample Problem 4.2

Three loads are applied to a beam as shown. The beam is supported by a roller at A and by a pin at B. Neglecting the weight of the beam, determine the reactions at A and B when  $P = 15$  kips.



$$\sum M_{\textcircled{B}} = 0 \quad \curvearrowleft +$$

$$-A_y * 6 + 15 * 6 - 6 * 2 - 6 * 4 = 0$$

$$A_y = 6 \text{ kips}$$

$$\sum F_x = 0 \quad \rightarrow +$$

$$B_x = 0$$

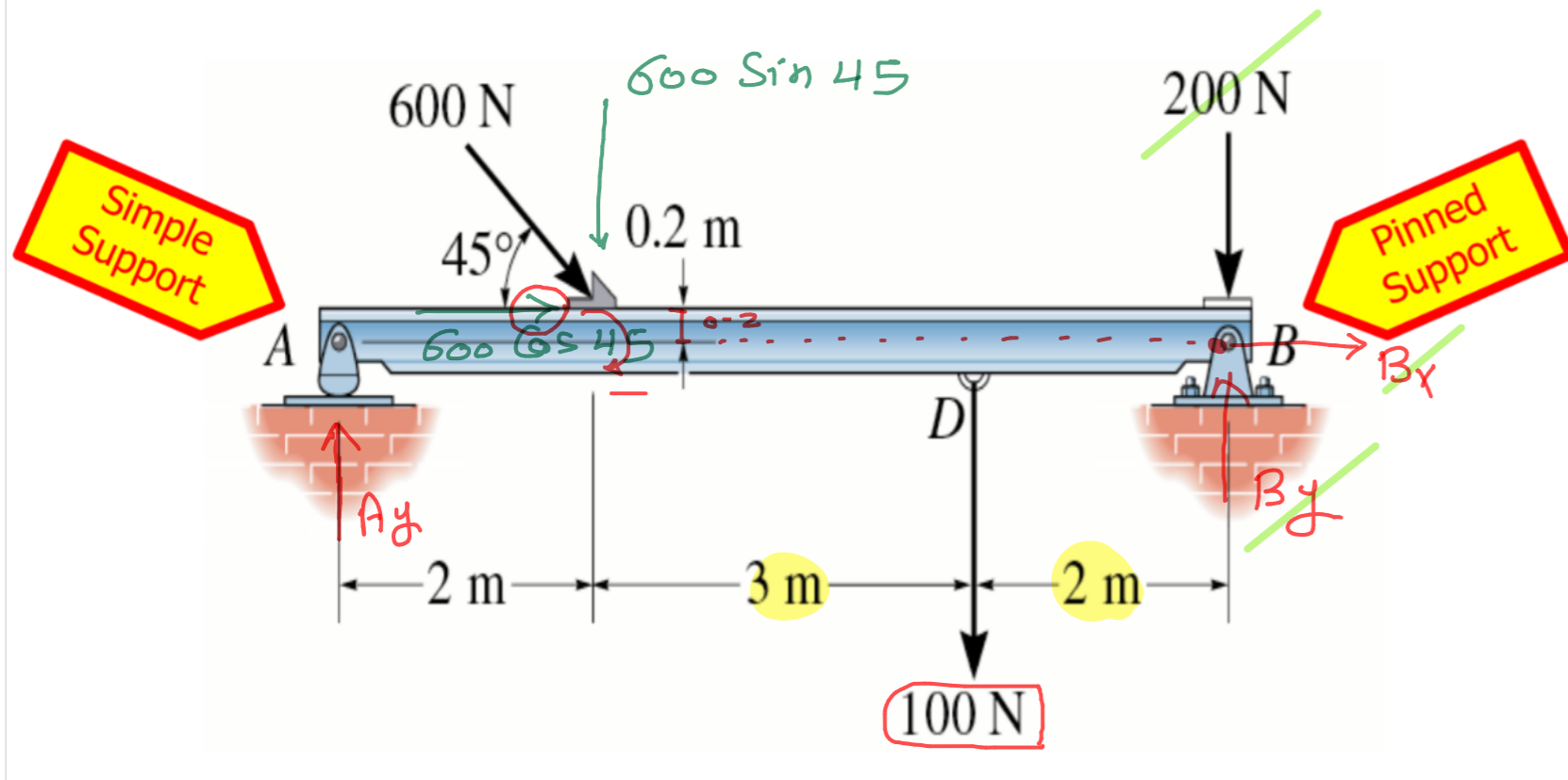
$$\sum F_y = 0 \quad \uparrow +$$

$$6 - 15 + B_y - 6 - 6 = 0$$

$$B_y = 21 \text{ kips}$$

## Example

Determine the reactions at the supports – the beam's mass is negligible.



$$\sum M_B = 0 \quad \curvearrow +$$

$$+ 100 * 2 + 600 \sin 45 * 5 - 600 \cos 45 * 0.2 - A_y * 7 = 0$$

$$A_y = 319 \text{ N}$$

$$\sum F_x = 0 \quad \rightarrow$$

$$600 \cos 45 + B_x = 0$$

$$B_x = -424 \text{ N}$$

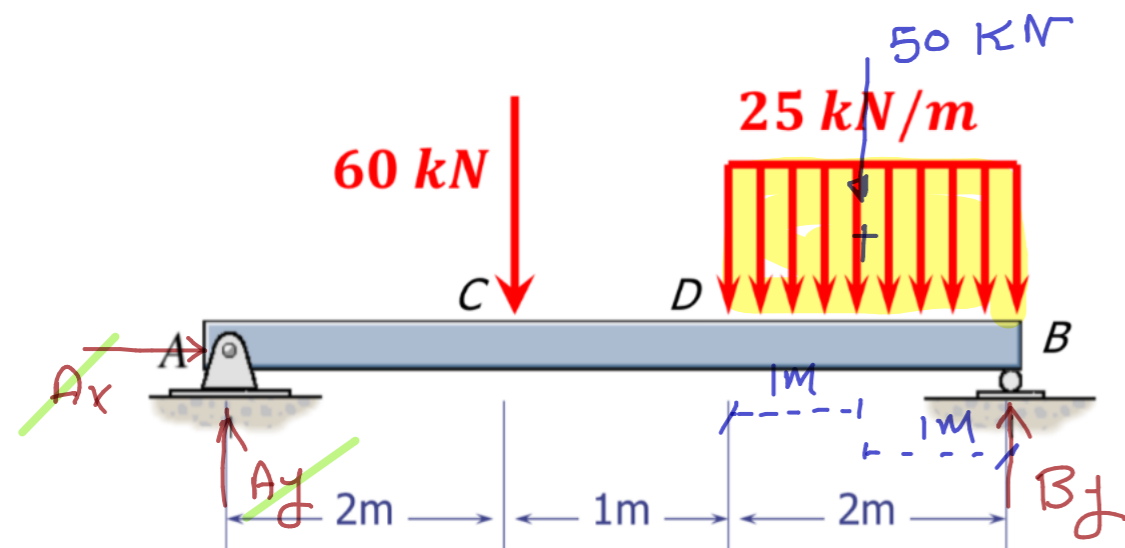
$$B_x = 424 \text{ N} \quad \leftarrow$$

$$\sum F_y = 0 \quad \uparrow +$$

$$319 - 600 \sin 45 - 100 - 200 + B_y = 0$$

$$B_y = 405 \text{ N}$$

**Example 1:** Determine the reactions at the supports.



$$\sum M_A = 0 \quad \curvearrowright +$$

$$- 60 * 2 - 50 * 4 + B_y * 5 = 0$$

$$B_y = 64 \text{ kN}$$

$$\sum F_x = 0 \quad \rightarrow +$$

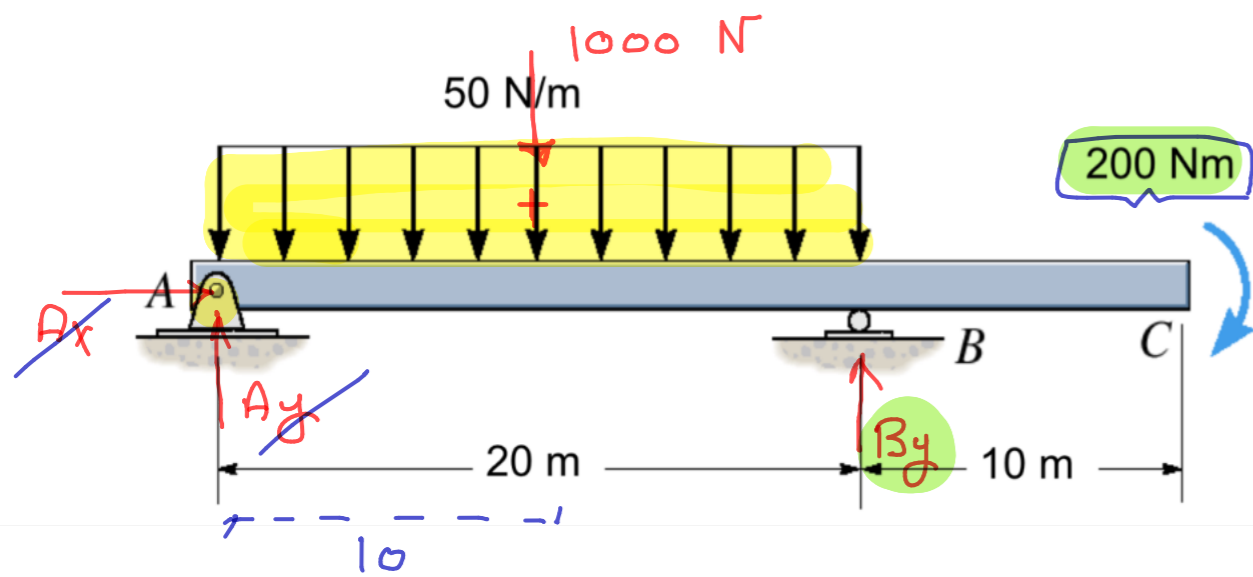
$$A_x = 0$$

$$\sum F_y = 0 \quad \uparrow +$$

$$A_y - 60 - 50 + 64 = 0$$

$$A_y = 46 \text{ kN}$$

**Example 2:** Determine the reactions at the supports.



$$\sum M_A = 0 \quad \curvearrowright +$$

$$- 1000 \times 10 + B_y \times 20 - 200 = 0$$

$$B_y = 510 \text{ N}$$

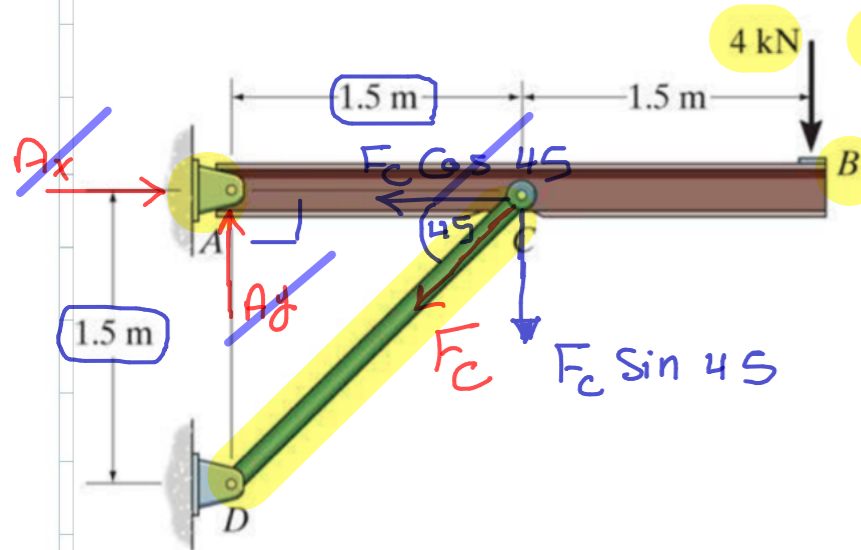
$$\sum F_x = 0 \quad \rightarrow +$$

$$A_x = 0$$

$$\sum F_y = 0 \quad \uparrow +$$

$$A_y - 1000 + 510 = 0$$

$$A_y = 490 \text{ N}$$



**Given:** The 4-kN load at B of the beam is supported by pins at A and C. Assume DC to be like a cable.

**Find:** The support reactions at A and C.

**Plan:**

$$\sum M_A = 0 \quad \curvearrowright +$$

$$- F_C \sin 45 \cdot 1.5 - 4 \cdot 3 = 0$$

$$F_C = -11.3 \text{ kN}$$

$$F_C = 11.3 \text{ kN} \quad \text{Compression}$$

$$\sum F_x = 0 \quad \rightarrow +$$

$$A_x - F_C \cos 45 = 0$$

$$A_x - (-11.3) \cos 45 = 0$$

$$A_x = -8 \text{ kN}$$

$$A_x = 8 \text{ kN} \quad \leftarrow$$

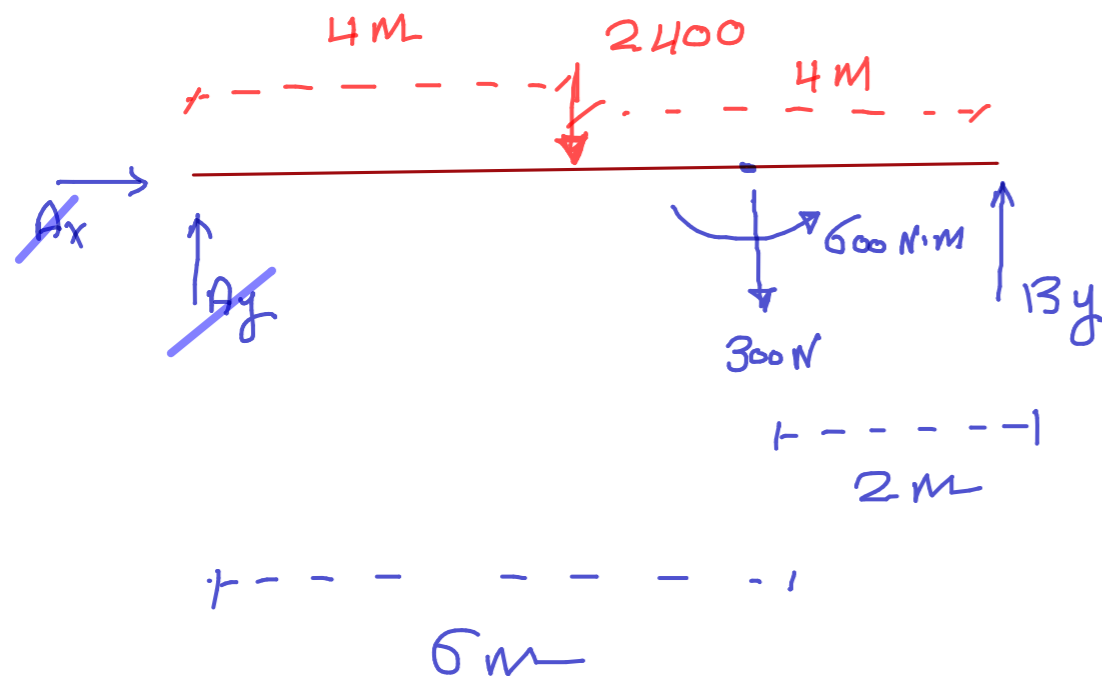
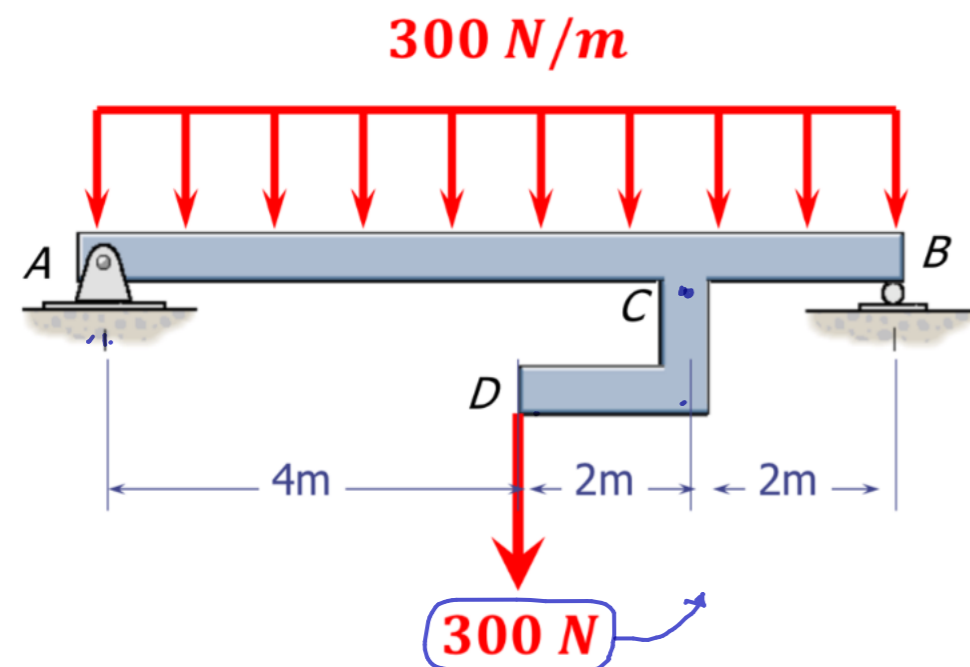
$$\sum F_y = 0 \quad \uparrow +$$

$$A_y - (-11.3) \sin 45 - 4 = 0$$

$$A_y = -4 \text{ kN}$$

$$A_y = 4 \text{ kN} \quad \downarrow$$

**Example 3:** Determine the reactions at the supports.



$$\sum M_A = 0 \quad \curvearrowleft +$$

$$-2400 \times 4 - 300 \times 6 + 600 + B_y \times 8 = 0$$

$$B_y = 1350 \text{ (N)}$$

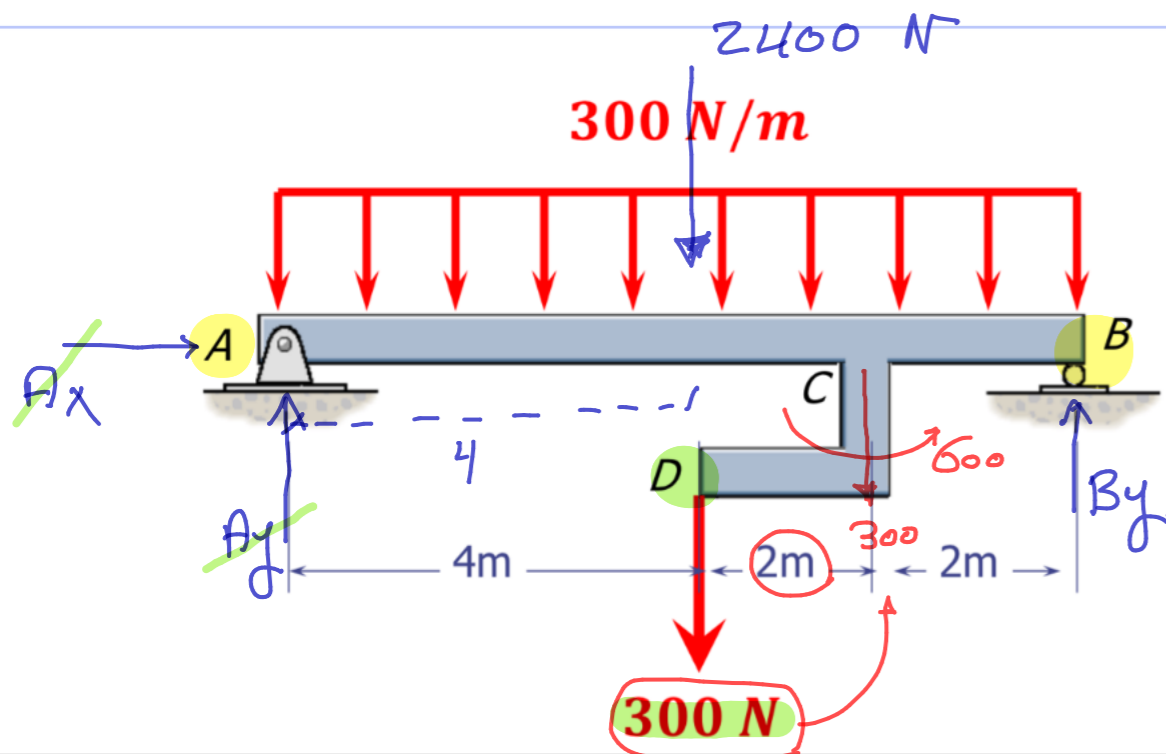
$$\sum F_x = 0 \quad \rightarrow \quad A_x = 0$$

$$\sum F_y = 0 \quad \uparrow +$$

$$A_y - 2400 - 300 + 1350 = 0$$

$$A_y = 1350 \text{ (N)}$$

**Example 3:** Determine the reactions at the supports.



$$\sum M_A = 0 \quad \curvearrowleft +$$

$$- 2400 \times 4 - 300 \times 4 + B_y \times 8 = 0$$

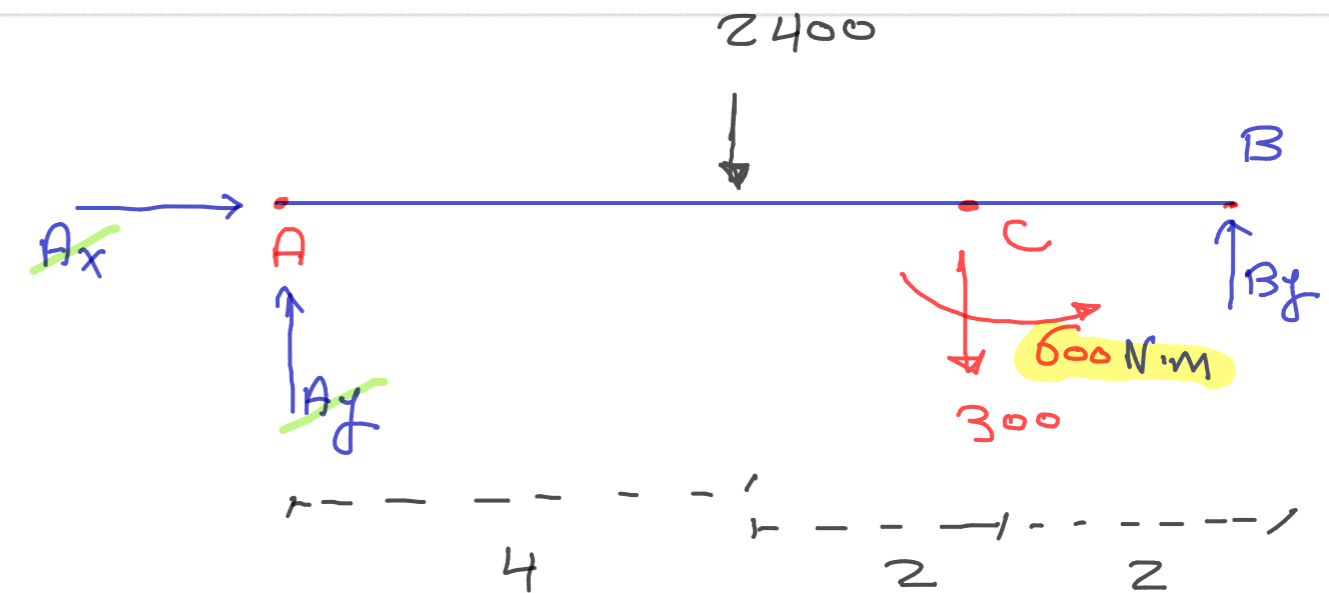
$$B_y = 1350 \text{ N}$$

$$\sum F_x = 0 \quad \rightarrow + \quad A_x = 0$$

$$\sum F_y = 0 \quad \uparrow +$$

$$A_y - 2400 - 300 + 1350 = 0$$

$$A_y = 1350 \text{ N}$$



$$\sum M_A = 0 \quad \curvearrowleft +$$

$$- 2400 \times 4 - 300 \times 6 + 600 + B_y \times 8 = 0$$

$$B_y = 1350 \text{ N}$$

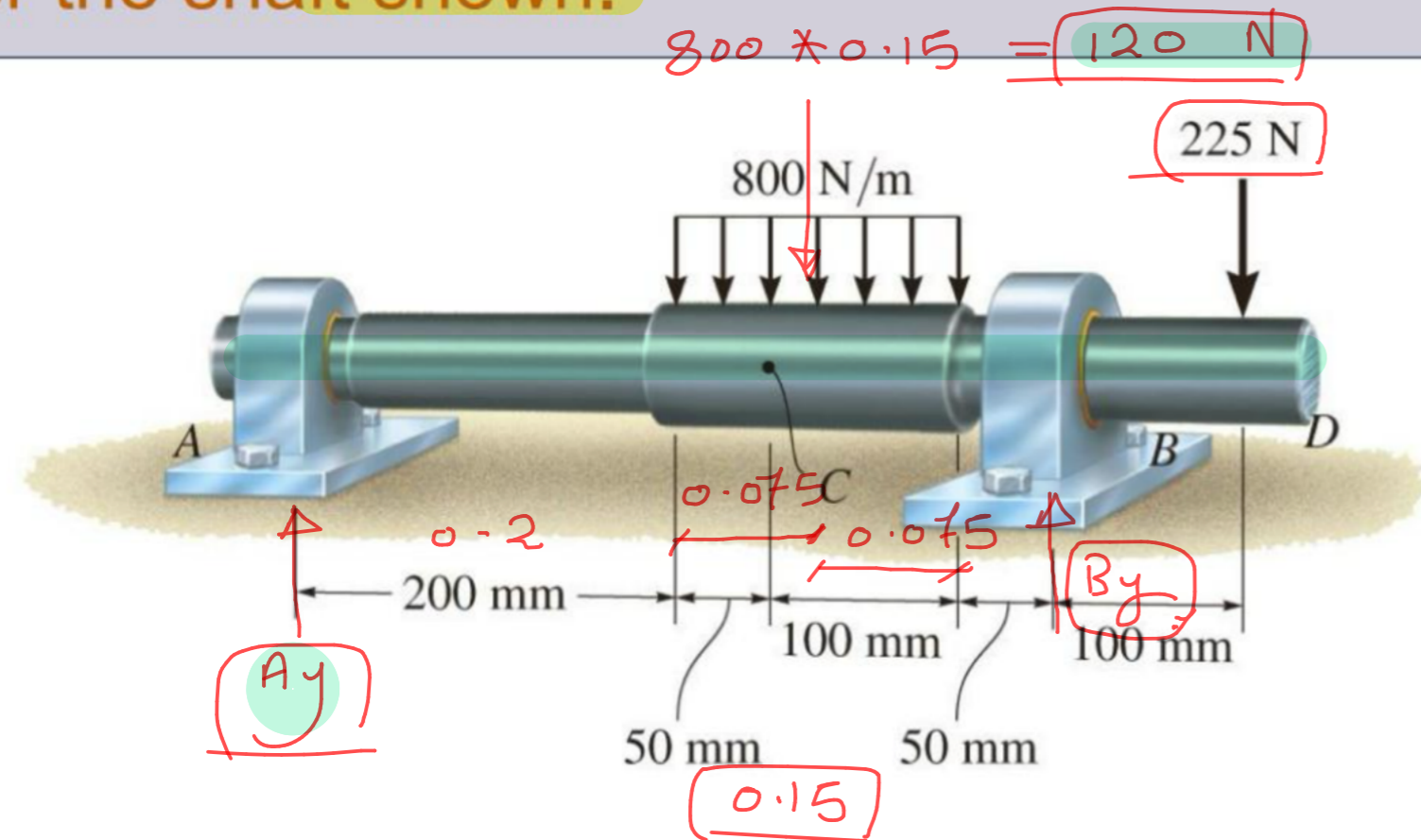
$$\sum F_x = 0 \quad \rightarrow + \quad A_x = 0$$

$$\sum F_y = 0 \quad \uparrow +$$

$$A_y - 2400 - 300 + 1350 = 0$$

$$A_y = 1350 \text{ N}$$

Example: Find the vertical reactions at A and B for the shaft shown.



$$\sum M_A = 0 \quad \downarrow +$$

$$-120 \times 0.275 + B_y \times 0.4 - 225 \times 0.5 = 0$$

$$\Downarrow$$

$$B_y = 363.75 \text{ N}$$

$$\sum F_y = 0 \quad \uparrow +$$

$$A_y - 120 + 363.75 - 225 = 0$$

$\Downarrow$

$$A_y = -18.75 \text{ N}$$

$$A_y = 18.75 \text{ N} \quad \downarrow$$

\* \*  
\* \*

**Example:**

Consider the structure which was designed to support a 30-kN load. It consists of a boom AB with a 30 x 50-mm rectangular cross section and a rod BC with a 20-mm-diameter circular cross section. These are connected by a pin at B and are supported by pins and brackets at A and C respectively. Find Force on Pins A, B and C.

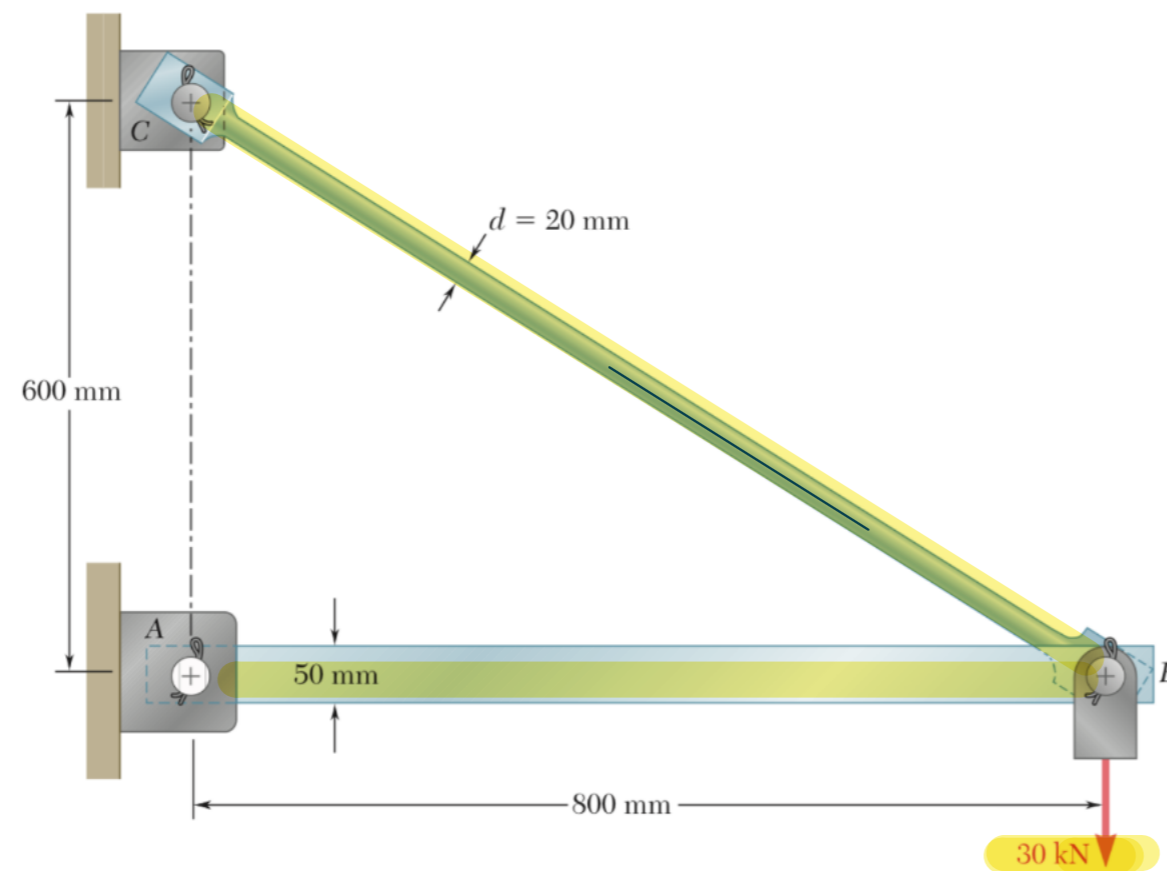


Fig. 1.1 Boom used to support a 30-kN load.

1.2

\*  $\sum F_x = 0 \rightarrow$

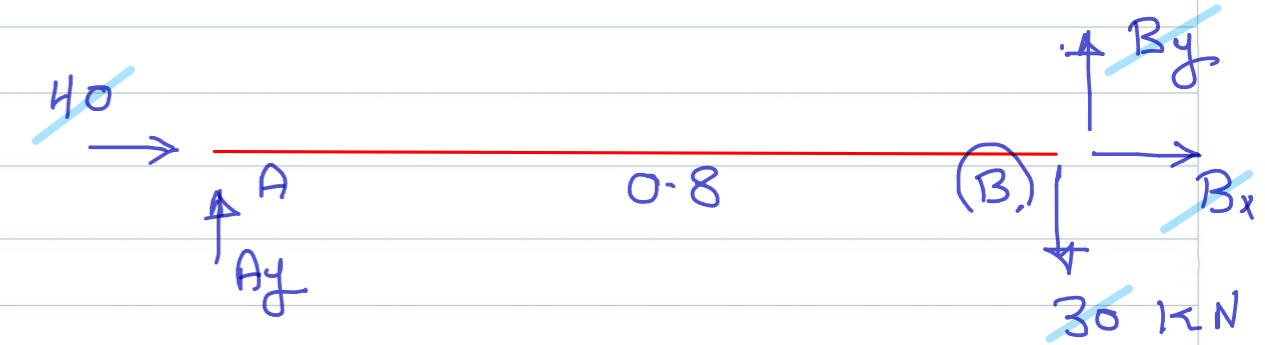
$$A_x + C_x = 0$$

$$C_x = -40 \text{ kN}$$

\*  $\sum F_y = 0 \uparrow +$

$$A_y + C_y - 30 = 0$$

$$A_y + C_y = 30 \Rightarrow \textcircled{1}$$



$\sum M_B = 0 \curvearrow +$

$$-A_y \times 0.8 = 0$$

$$A_y = 0$$

in Eq<sup>n</sup>  $\textcircled{1}$   $C_y = 30$

$\sum F_x = 0 \rightarrow$

$$40 + B_x = 0$$

$$B_x = -40 \text{ kN}$$

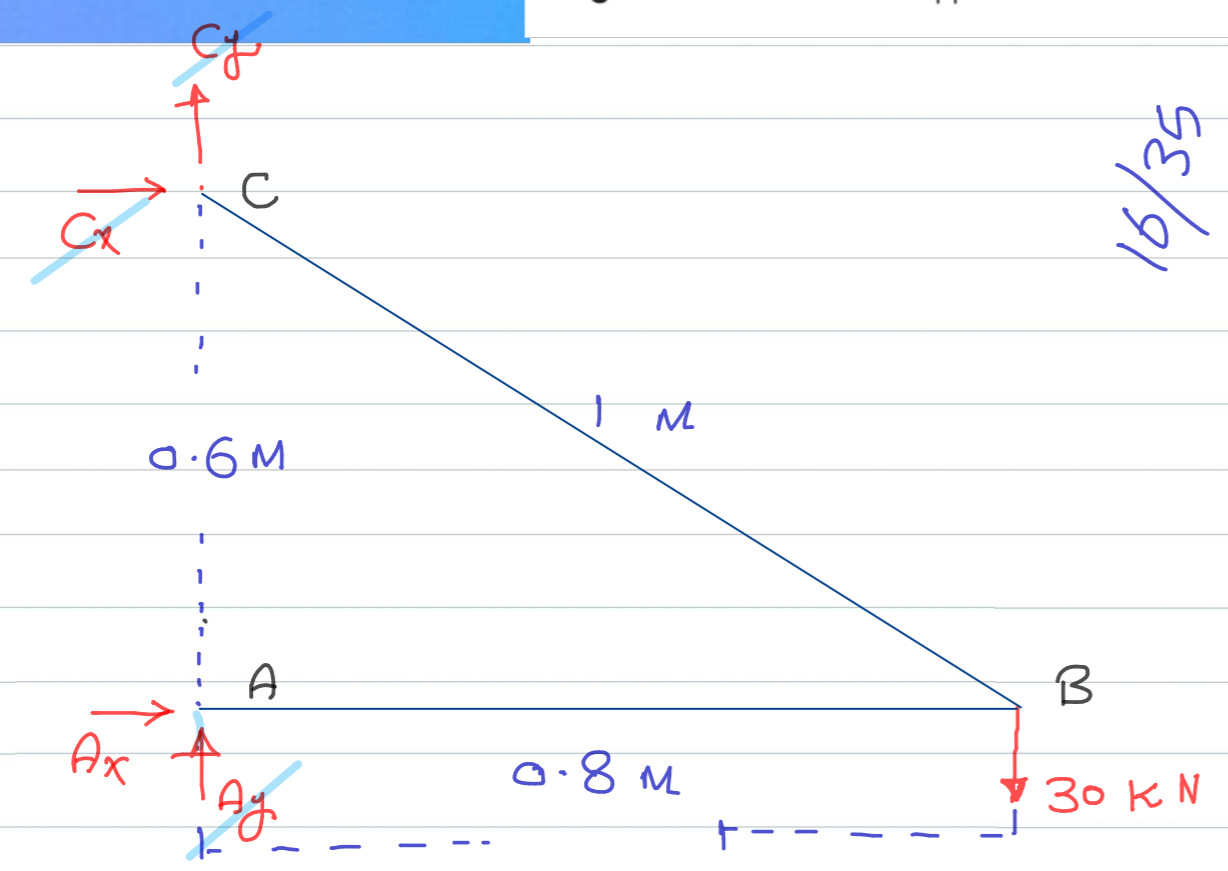
$\sum F_y = 0 \uparrow +$

$$0 - 30 + B_y = 0$$

$$B_y = 30 \text{ kN}$$

$B = \sqrt{B_x^2 + B_y^2}$

$\Theta = \tan^{-1} \frac{30}{-40}$

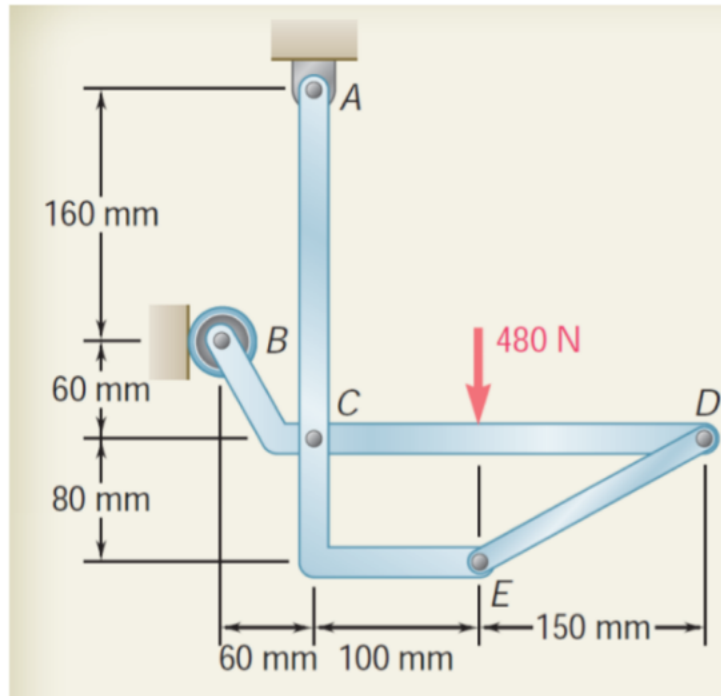


\*  $\sum M_C = 0 \curvearrow +$

$$A_x \times 0.6 - 30 \times 0.8 = 0$$

## FBD and solving for reactions- exercise in class

COLLEGE



- As engineers, we will need to design the frame shown.
- Design does not mean drawing only.
- It also means selecting the correct cross sectional areas and material selection.
- This will require us to understand how external forces are acting on each member

