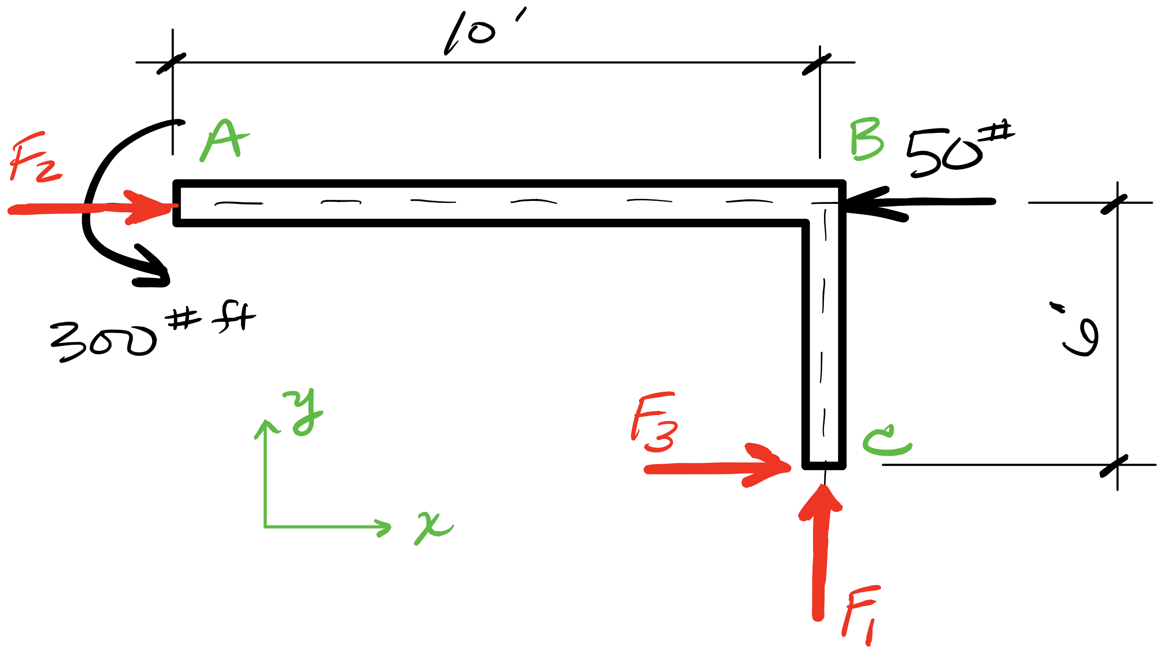


CONSIDERING WHAT IS BEING ASKED FOR, VISUALLY INSPECT THE FBD FOR A LOCATION TO SUM MOMENTS, YIELDING AN EFFICIENT EQUATION OF EQUILIBRIUM.

FOR THE FBD ABOVE, HERE ARE THE BEST

OPTIONS TO START YOUR ANALYSIS.

EQUATION	UNKNOWN
$\Sigma M_{\text{AT PT. B}} = 0$	F_3
$\Sigma M_{\text{AT PT C}} = 0$	F_2
$\Sigma F_y = 0$	F_1

INEFFICIENT STARTING OPTIONS

$\Sigma F_x = 0$	F_2 & F_3
$\Sigma M_{\text{AT PT A}} = 0$	F_1 & F_3
$\Sigma M_{\text{2 FT ABOVE PT B}} = 0$	F_2 & F_3
$\Sigma F_{45^\circ} = 0$	F_1, F_2 & F_3
$\Sigma M_{\text{3 feet BELOW PT A}} = 0$	F_1, F_2 & F_3

The equations of equilibrium can be thought of as a “transformer” to move from a picture to an equation. The picture (the FBD) must be transformed through a set of rules to yield an equation that will give us insights into the FBD. The insights may give us answers for the unknowns on the FBD or an affirmation of equilibrium - an independent statics check - confirming that indeed the object is in a state of equilibrium.

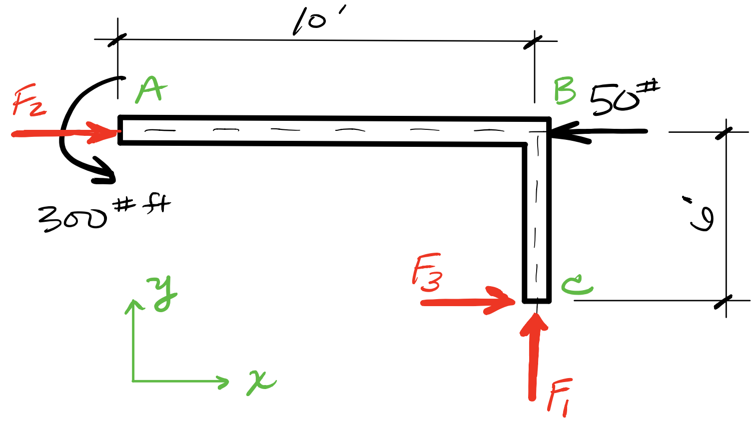
The “transformer” must specifically express the quantity being considered (force or moment). If a force, it must declare the direction of the forces and if a moment, it must declare the location that the moment is being calculated. Both forces and moments must state the sense of the direction for positive.

$\overset{+}{\rightarrow} \Sigma F_x$ $\qquad$ $\overset{+}{\nearrow} \Sigma F_{x'}$ $\qquad$ $+\!\downarrow \Sigma F_y$

$\circlearrowright + \Sigma M_{\text{AT PT A}}$ $\qquad$ $\overset{+}{\swarrow} \Sigma M_{\substack{\text{z-axis} \\ \text{Thru pt B}}}$

$\circlearrowleft + \Sigma M_{\substack{\text{AT 3 Feet} \\ \text{Left of pt B}}}$ $\qquad$ $+\!\downarrow \Sigma M_{\substack{\text{y-axis} \\ \text{Thru pt C}}}$

With this clear declaration, the FBD is now represented in equation form as a means to solve for the unknowns present on the diagram. **ANY NUMERICAL ANSWER RELATES TO THE FBD DRAWING.** The numerical answers, specifically if they are positive or negative, relates to the direction of the force or moment as it is drawn on the FBD. To maintain order and clarity in the calculations, you will often see the FBD redrawn with the unknowns solved for (“turned black”) The red arrows, orange arrows or purple arrows are just place holders for the numbers and senses that will replace the unknowns in due time.



$\circlearrowleft + \Sigma M_{AT\ PT\ B} = 0$

$-300^{\#'} - F_3 \times 6' = 0$

$F_3 = -50^{\#}$

or

$50^{\#} \leftarrow$

— OR —

$\circlearrowright + \Sigma M_{AT\ PT\ B} = 0$

$+300^{\#'} + F_3 \times 6' = 0$

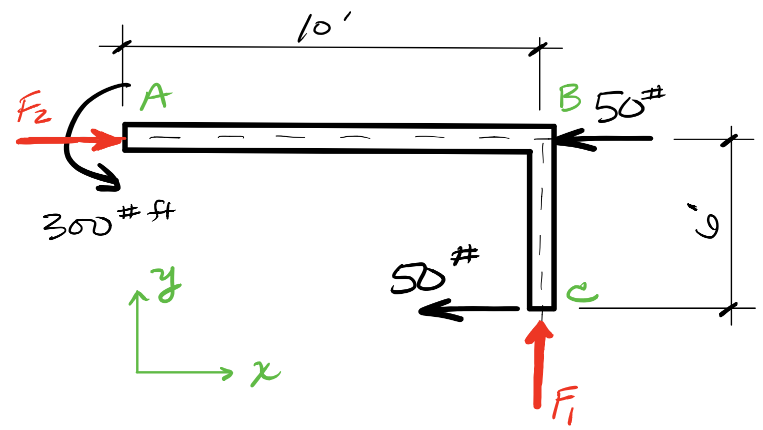
$F_3 = -50^{\#}$

or

$50^{\#} \leftarrow$

— SAME ANSWER —

NOW THE FBD LOOKS LIKE



$\circlearrowleft + \Sigma M_{AT\ PT\ C} = 0$

$-300^{\#'} - 50^{\#} \cdot 6' + F_2 \cdot 6' = 0$

$F_2 = +100^{\#}$ or

$100^{\#} \rightarrow$

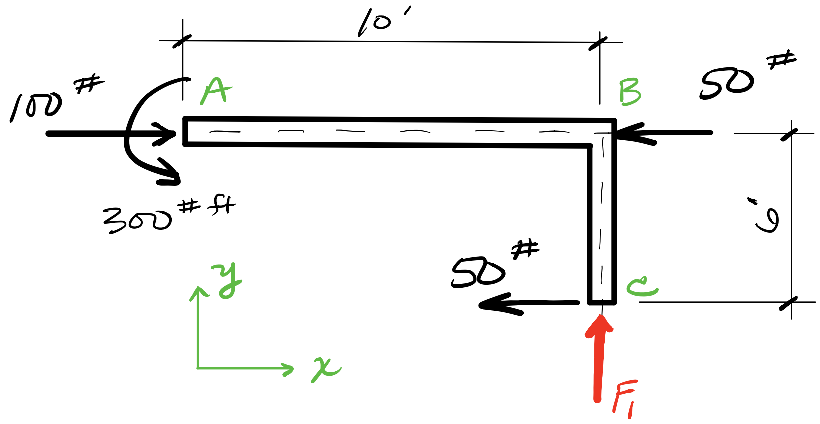
— OR —

$\circlearrowright + \Sigma M_{AT\ PT\ C} = 0$

$+300^{\#'} + 50^{\#} \cdot 6' - F_2 \cdot 6' = 0$

$F_2 = +100^{\#}$ or

$100^{\#} \rightarrow$

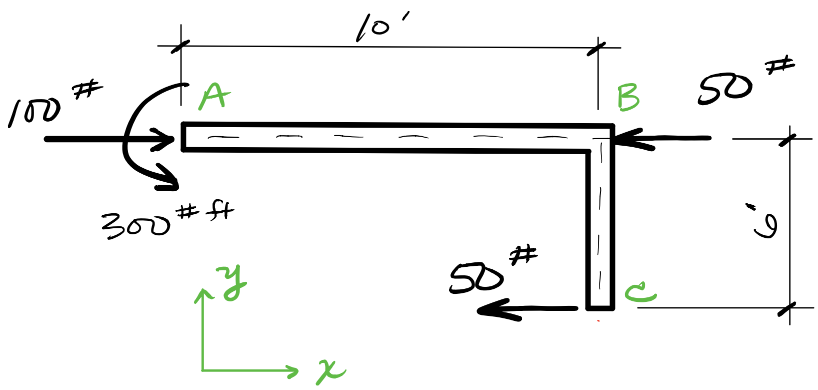


$$\circlearrowright + \Sigma M_{\text{AT PT A}} = 0$$

$$+300^{\#'} - 50^{\#} \cdot 6' + F_1 \cdot 10' = 0$$

$$F_1 \cdot 10' = 0$$

$$F_1 = 0$$



To get to this point, we have used three equations. We have summed moments at pt A, pt B and pt C. Each equation has been efficient - yielding a single unknown. We now have a solved FBD. However, we still have an infinite number of equations that will be satisfied if the solved FBD is in equilibrium. Let's choose any equation that has not already been used. The best equations to use here are ones that involve every force present on the FBD. For instance, if we sum moments halfway between points A and B, the 50# force at B and the 100# force at point A will not be present in the equation as they have a zero lever arm. But, summing moments 3 feet above the halfway point between A and B involves every force on the FBD and since they are all black arrows, that is good. The independent statics check will be thorough.

$$\circlearrowright + \Sigma M_{\text{6' ABOVE MIDWAY SEGMENT AB}} = 0$$

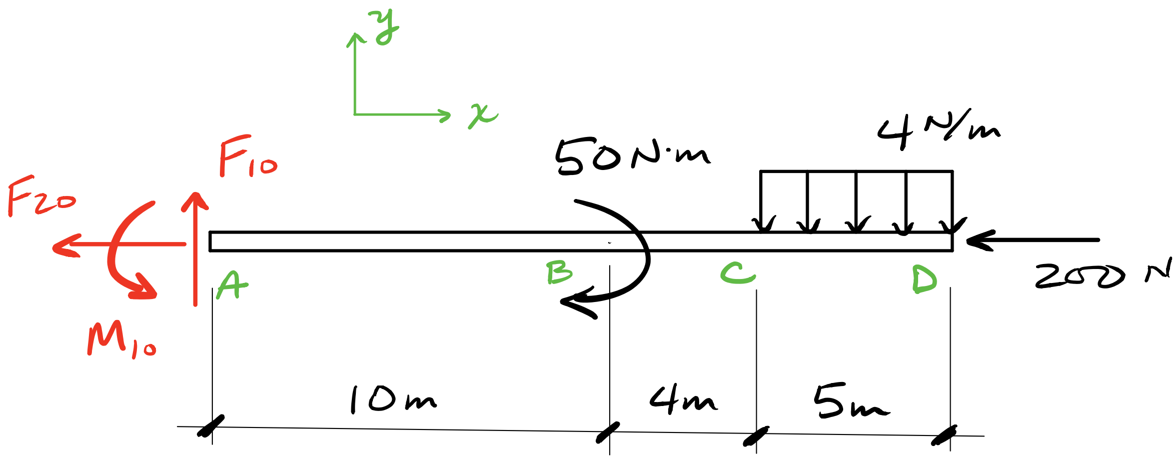
$$-300^{\#'} - 100^{\#} \cdot 3' + 50^{\#} \cdot 3' + 50^{\#} \cdot 9' = 0$$

$$-300^{\#'} - 300^{\#'} + 150^{\#'} + 450^{\#'} = 0$$

$0 = 0$ ✓✓

$\Rightarrow$ EQUILIBRIUM CONFIRMED!

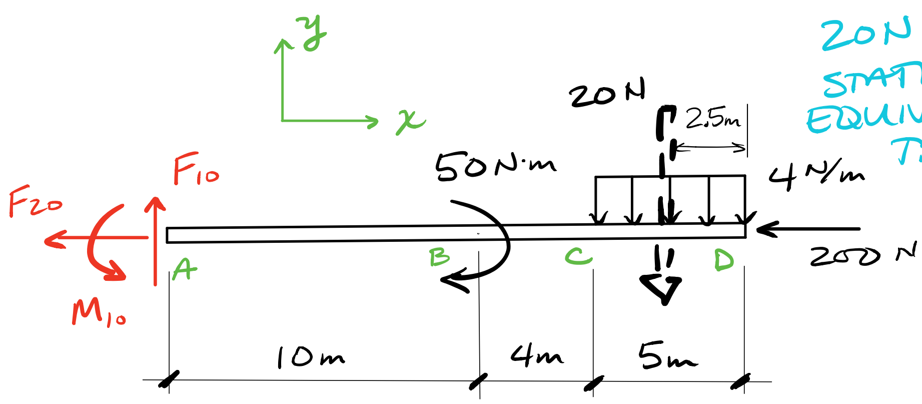
ANOTHER EXAMPLE



$\Sigma M_{AT\ PT\ A} = 0$ $\quad M_{10}$

$\Sigma F_x = 0$ $\quad F_{20}$

$\Sigma F_y = 0$ $\quad F_{10}$



20N LOAD IS STATICALLY EQUIVALENT TO THE DISTRIBUTED LOAD <LINK 4>

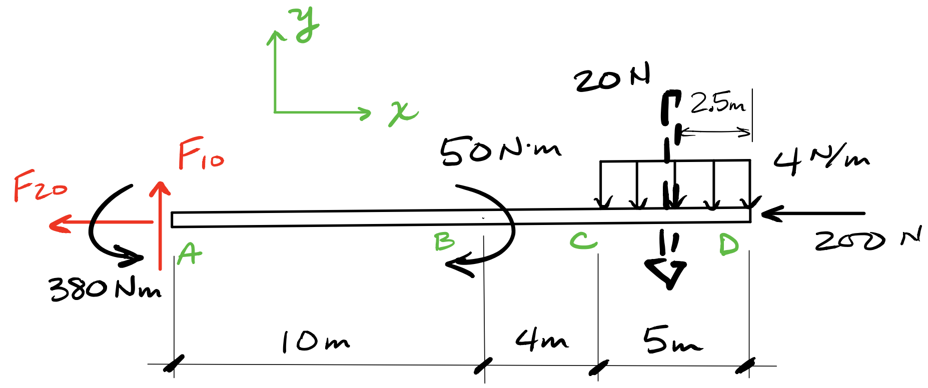
$\circlearrowleft + \Sigma M_{AT\ PT\ A} = 0$

$$-M_{10} + 50\ Nm + 20N \cdot (14m + 2.5m) = 0$$

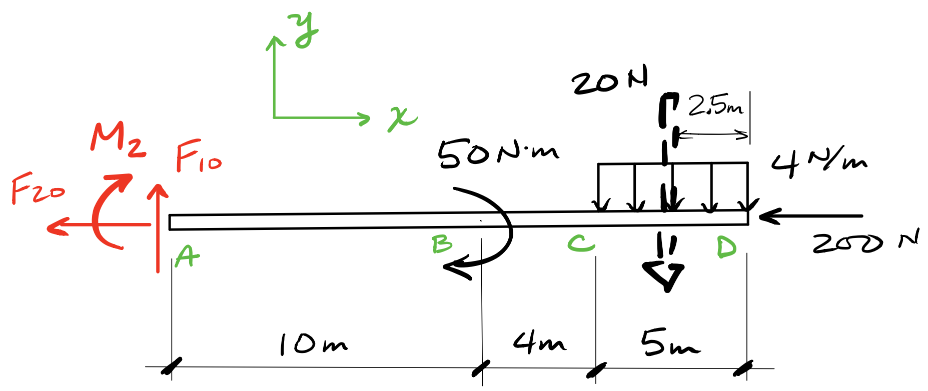
$$-M_{10} = -380\ Nm$$

$$M_{10} = 380\ Nm$$

or $380\ Nm \circlearrowleft$



ASIDE: IF THE INITIAL FBD WAS DRAWN DIFFERENT – BUT CORRECT:



$$\circlearrowleft + \Sigma M_{AT\ PT\ A} = 0$$

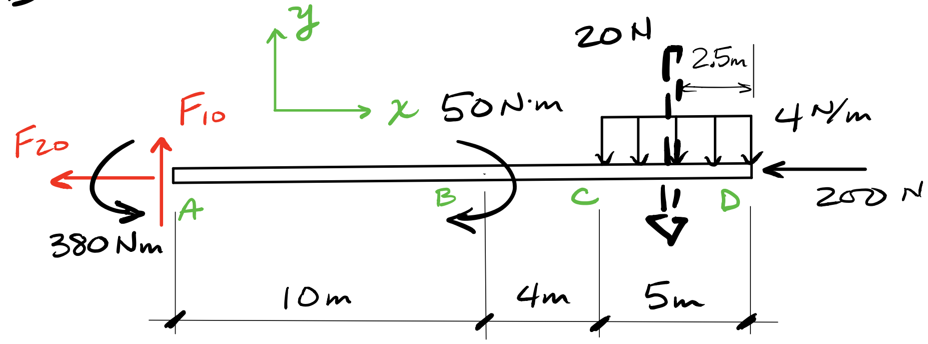
$$-M_2 - 50\,Nm - 20\,N\,(14m + 2.5m) = 0$$

$$-M_2 = +380\,Nm$$

$$M_2 = -380\,Nm$$

or $380\,Nm \circlearrowright$

FBD LOOKS THE SAME:



$$\circlearrowleft + \sum M_{\text{AT PT B}} = 0$$

$$-380\ Nm + 50\ Nm + F_{10} \cdot 10\,m + 20N \times (4m + 2.5m) = 0$$

$$F_{10} \cdot 10\,m = 200\ Nm$$

$$F_{10} = 20\ N$$

or $20N \uparrow$

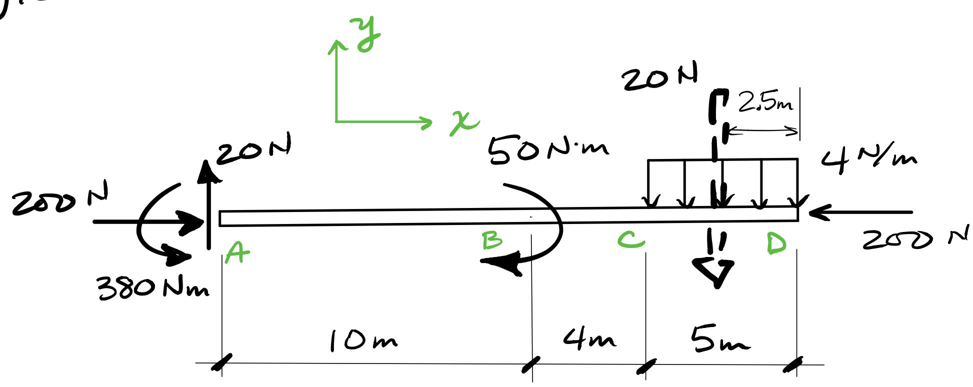
$$\overset{+}{\leftarrow} \sum F_x = 0$$

$$F_{20} + 200\ N = 0$$

$$F_{20} = -200\ N$$

or $200\ N \rightarrow$

YIELDING A SOLVED FBD:



INDEPENDENT STATICS CHECK:

$$\circlearrowleft + \sum M_{\text{2m BELOW PT. D}} = 0$$

$$+200N \cdot 2m + 20N \cdot 19m - 380\ Nm + 50\ Nm$$
$$- 20N \times 2.5m - 200N \cdot 2m = 0$$

$$0 = 0$$

$\Rightarrow$ EQUILIBRIUM CONFIRMED