



AL- ESRAA COLLEGE UNIVERSITY

Building & Construction Technology Engineering

Engineering Mechanics

First year

Couples

By

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Supervised by

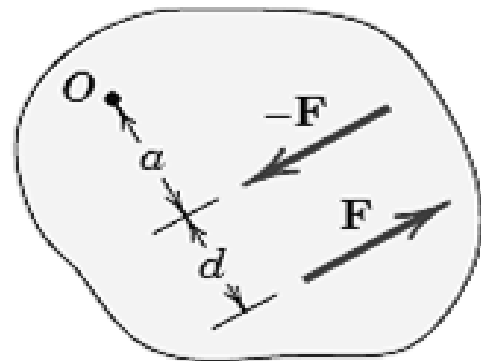
Dr. Ali Hussein

Couples

A couple is defined as two parallel forces [\mathbf{F} and $-\mathbf{F}$] that have the same magnitude, but opposite directions, and is separated by a perpendicular distance d .

The moment produced by a couple is called a couple moment. We can determine its value by finding the sum of the moments of both couple forces about any arbitrary point. For example, two equal and opposite forces \mathbf{F} and $-\mathbf{F}$ a distance d apart, as shown in Figure below. The couple moment determined about O is therefore.

$$\begin{aligned} \curvearrowright M &= F(a + d) - Fa \\ M &= Fd \end{aligned}$$



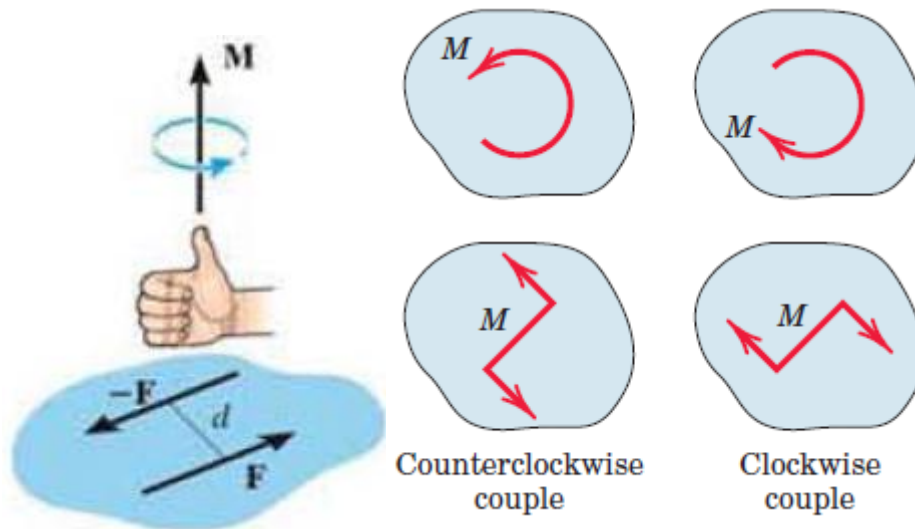
This result indicates that a couple moment is a free vector which can act at any point and depends only on d , not on the location of the point O .

Magnitude: The moment of a couple, \mathbf{M} , is defined as having a magnitude of

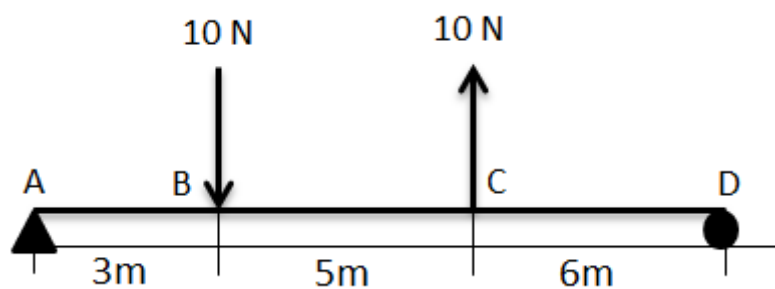
$$\mathbf{M} = F d$$

Where F is the magnitude of one of the forces and d is the perpendicular distance or moment arm between the forces.

Direction and sense: The Direction and sense of the couple moment are determined by the right-hand rule, where the thumb indicates this direction when the fingers are curled with the sense of rotation caused by the couple forces. In all cases, M will act perpendicular to the plane containing these forces.



Example: Determine the moment of a couple with respect to: (1) point A, (2) point B, (3) point C. (4) point D.



$$M_{couple} = Fd$$

$$(1) \curvearrowright +M_A = -(10)(3) + (10)(3 + 5) = 50 \text{ N.m} \curvearrowright$$

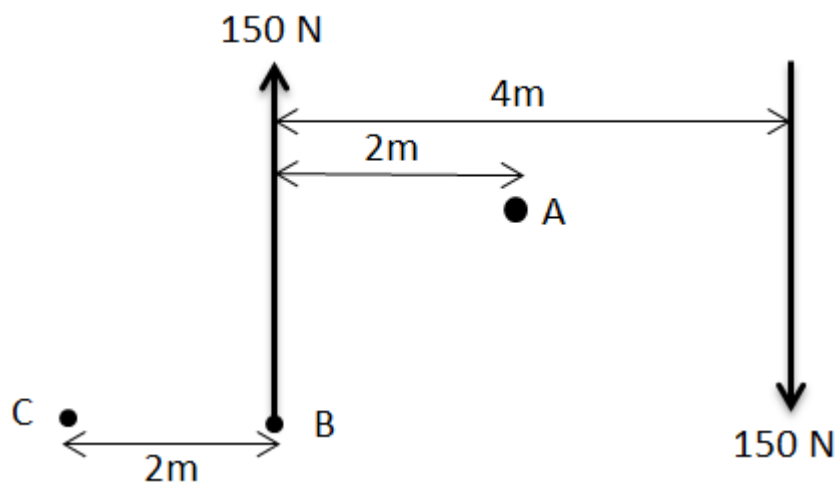
$$(2) \curvearrowright +M_B = (10)(5) = 50 \text{ N.m} \curvearrowright$$

$$(3) \curvearrowright +M_C = (10)(5) = 50 \text{ N.m} \curvearrowright$$

$$(4) \curvearrowright +M_D = (10)(5 + 6) - (10)(6) = 50 \text{ N.m} \curvearrowright$$

❖ The moment of a couple does not depend on the point one takes the moment about. In other words, a moment of a couple is the same about all points in space.

Example: Determine the moment of a couple with respect to: (1) point A, (2) point B, (3) point C.



$$(1) \curvearrowright +M_A = (150)(2) + (150)(2) = 600 \text{ N.M} \curvearrowright$$

$$(2) \curvearrowright +M_B = (150)(4) = 600 \text{ N.m} \curvearrowright$$

$$(3) \curvearrowright +M_C = (150)(4 + 2) - (150)(2) = 600 \text{ N.m} \curvearrowright$$

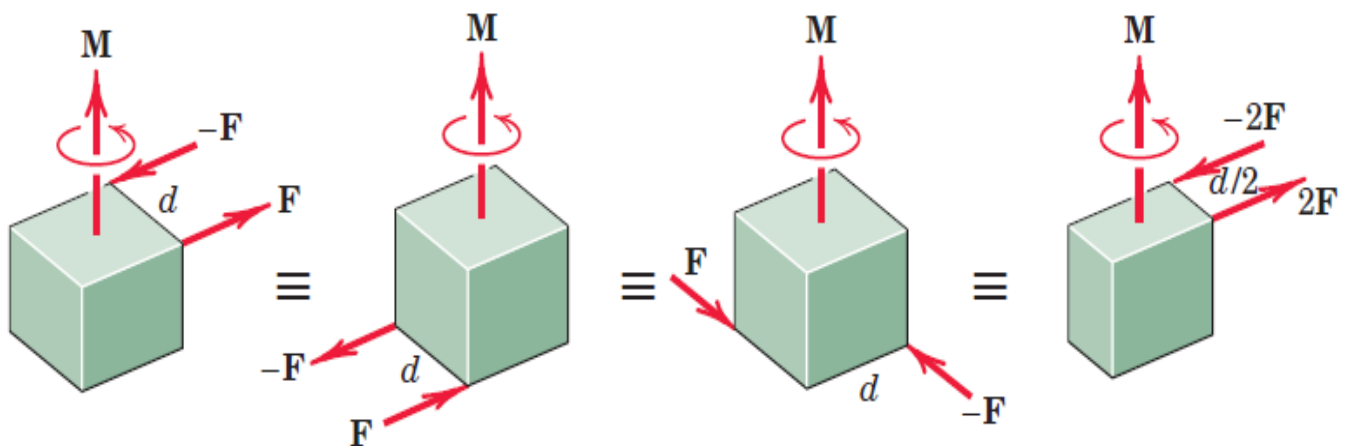
Transformation of Couples

Transformations of a couple are alteration of the couple that do not change any of its characteristics (the magnitude of the moment of the couple or the sense of the rotation of the couple).

Therefore, in the transformation process, we can change the following:

- 1- the plane which contains the forces to another parallel plane.
- 2- the magnitude of the forces.
- 3- the distance between the forces.

❖ The **magnitude** and the **direction** of the moment remain **constant**.

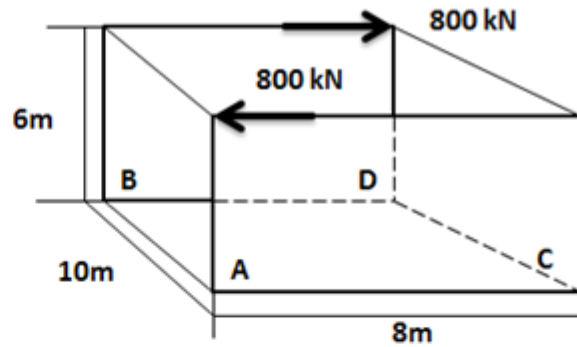


- ❖ From figure above shows four different configurations of the same couple M . Changing the values of F and d does not change a given couple as long as the product Fd remains the same. Likewise, a couple is not affected if the forces act in a different but parallel plane.

Example: By means of transformation of a couple, replace the couple shown in figure into an equivalent couple consisting of horizontal forces which act along AB and CD.

$$M_{couple} = Fd$$

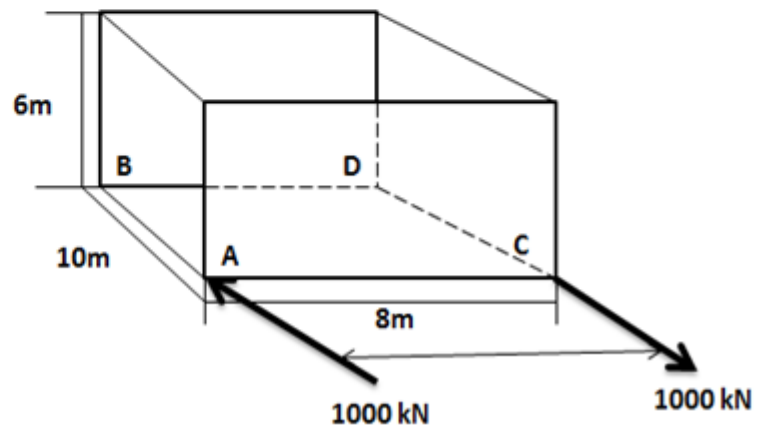
$$M = (800)(10) = 8000 \text{ kN.m}$$



$$M_{couple} = Fd$$


$$8000 = F(8)$$

$$F = 1000 \text{ kN}$$




Example: By using the transformation of a couple, replace the three couples shown in figure by one couple with the forces acting horizontally at A and B.

$$M_{couple} = Fd$$

Assume $\Sigma M +$ 

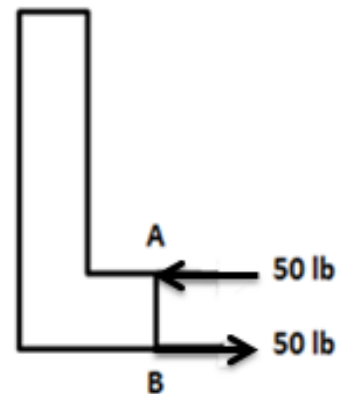
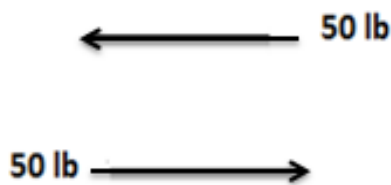
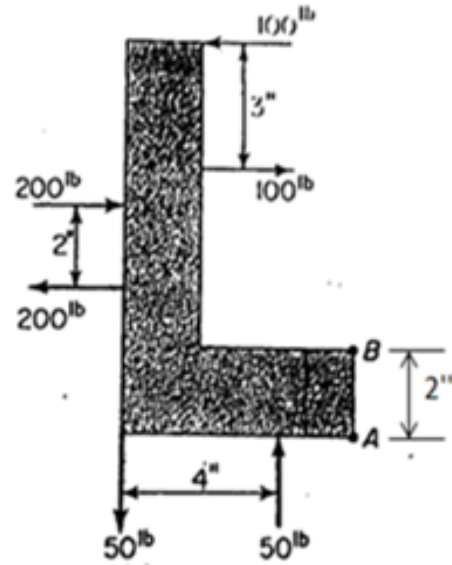
$$M = (200)(2) - (100)(3) - (50)(4)$$

$$M = -100 \text{ lb.in}$$

$$M = 100 \text{ lb.in}$$
 

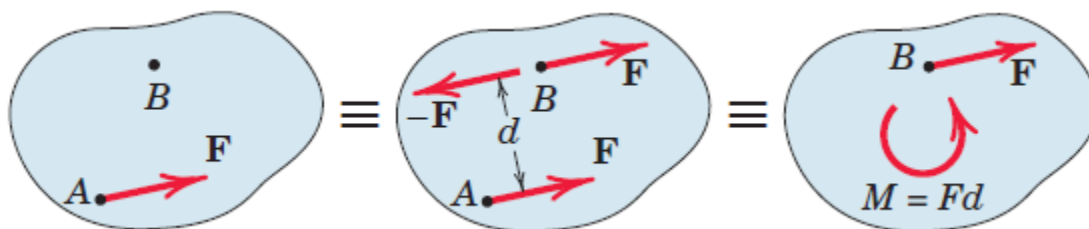
$$M_{couple} = Fd$$

$$100 = F(2) \rightarrow F = 50 \text{ lb}$$



Resolution of Forces in to a Force and Couple (Force-Couple System):

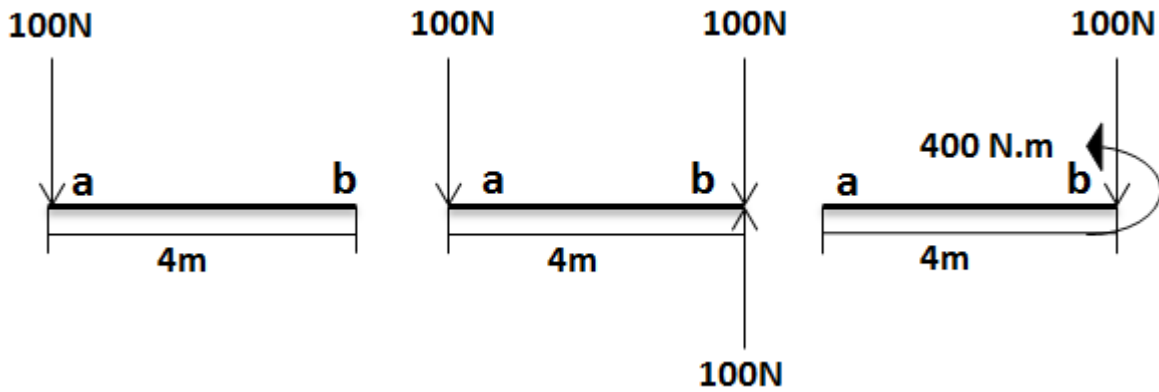
Consider a force F acting at point A on a rigid body. If this force is moved from point A to point B , this movement will cause a moment applied at point B instead of the action of the force. [The replacement of a force by a force and a couple is illustrated in figure below, where the given force F acting at point A is replaced by an equal force F at point B and the couple $M=F.d$].



As shown in figure above, to understand how to replaced (or moved) the original force at A by the same force acting at a different point B . We follow these steps:

- 1- The equal and opposite forces F and $-F$ are added at point B
 - 2- We now see that the original force at A and the equal and opposite one at B ($-F$) constitute the couple having a magnitude ($M= f.d$).
 - 3- Thus, we have replaced the original force at A by the same force acting at a different point B and a couple ($M= f.d$).
- ❖ The combination of the force and couple at point B is referred to as a **force–couple system**.

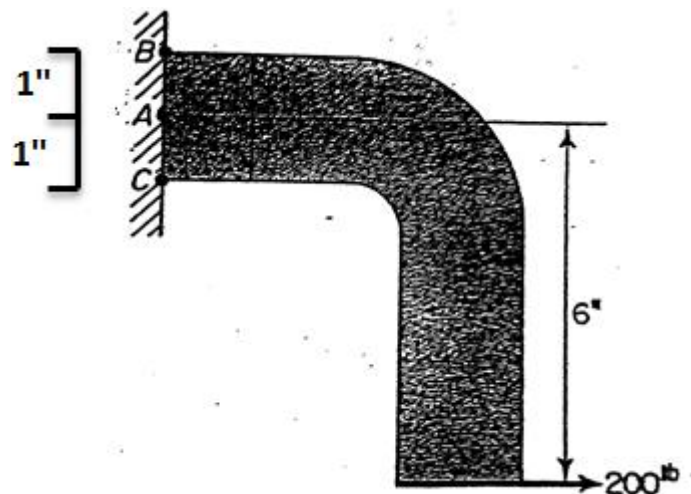
Example: Replace the force 100N by an equivalent force –couple system at point B.



$$M_{couple} = Fd$$

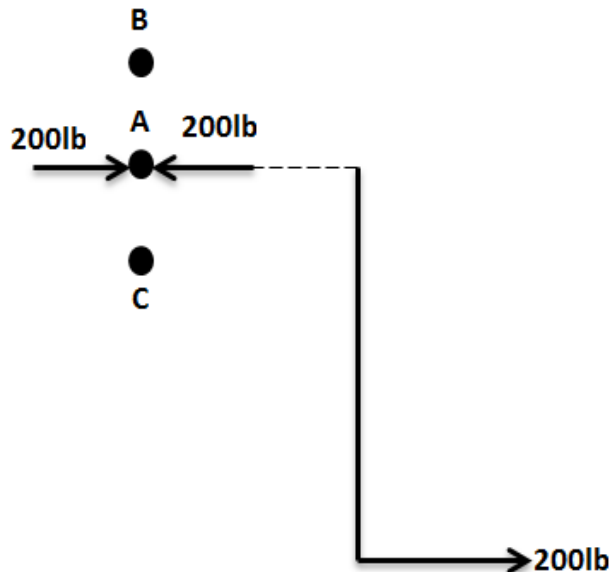
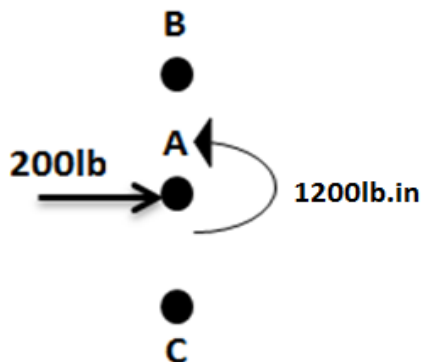
$$M_B = (100)(4) = 400 \text{ N.m}$$

Example: Replace the 600-lb force of figure shown below by a force through A and a couple whose forces act vertically through points B and C.



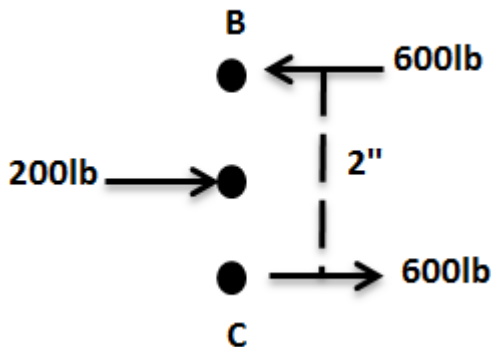
$$M_{couple} = Fd$$

$$M_{couple} = (200)(6) = 1200 \text{ lb.in}$$

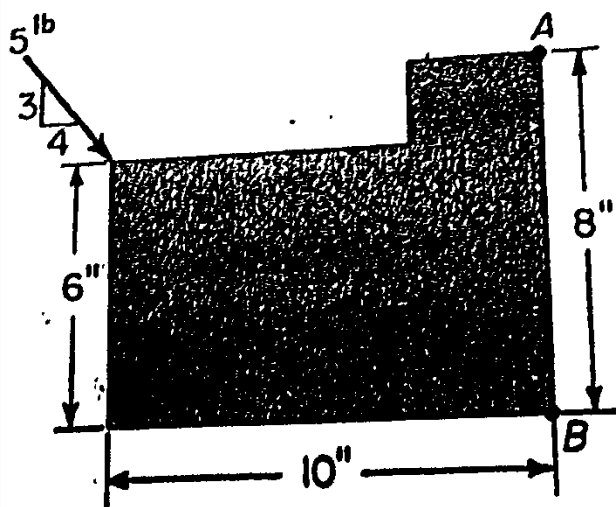


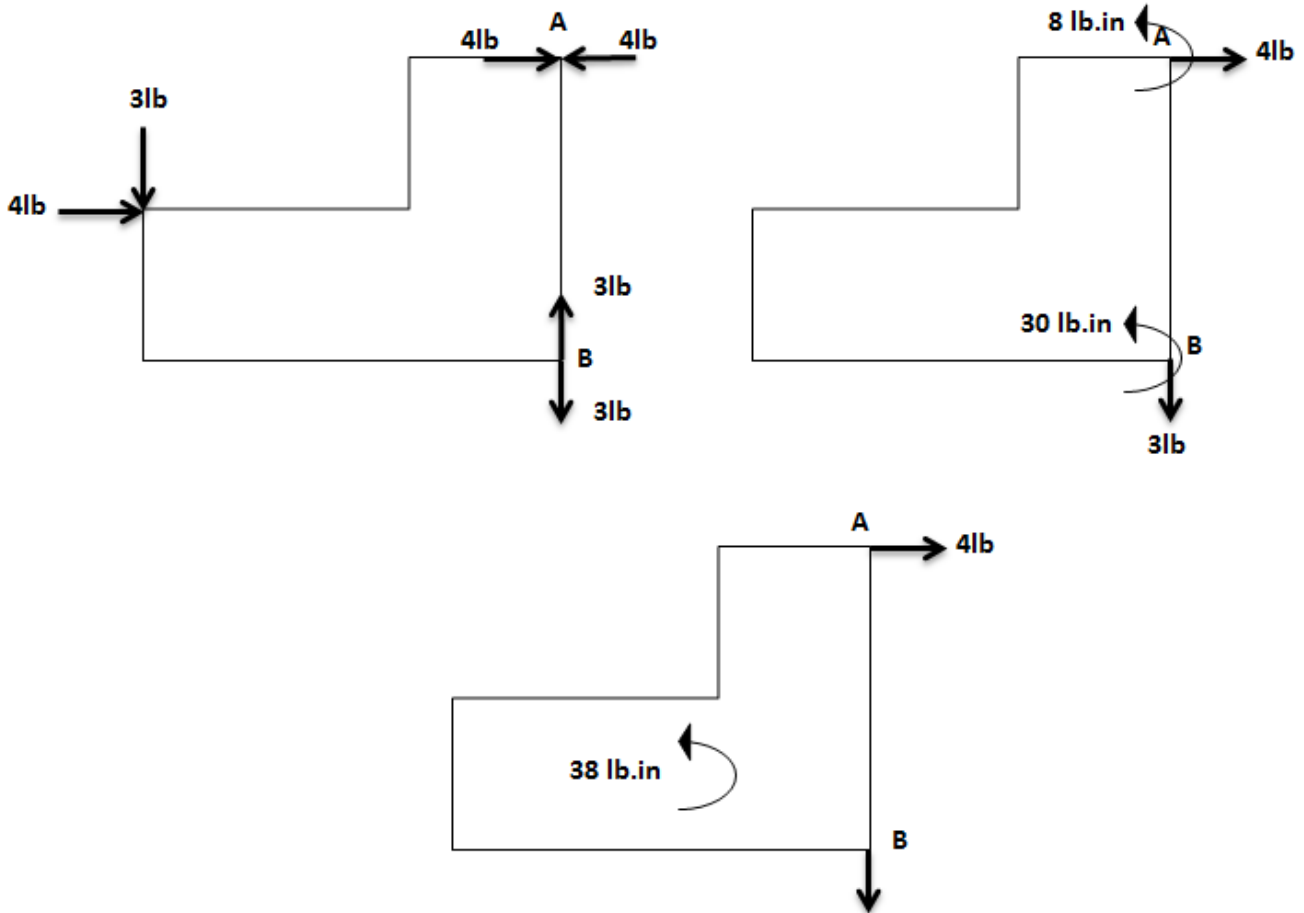
$$M_{couple} = Fd$$

$$1200 = F(2) \rightarrow F = 600 \text{ lb}$$



Example: Replace the single force of figure shown below by a horizontal force through A, a vertical force through B, and a couple.





$$M_{couple} = Fd$$

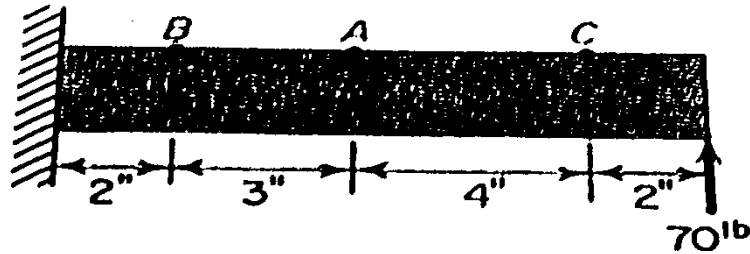
$$M_{couple@A} = (4)(2) = 8 \text{ lb.in}$$

$$M_{couple@B} = (3)(10) = 30 \text{ lb.in}$$

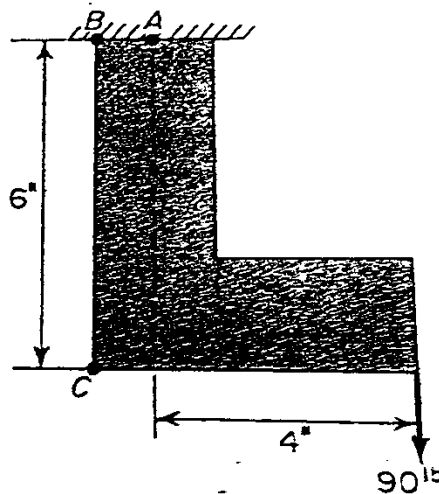
$$M_{coupleTotal} = 8 + 30 = 38 \text{ lb.in}$$

Home Work (4):

1- By means of the transformation of a couple, replace the 70 lb force by a force through A and a couple whose forces act vertically through points B and C.



2- Replace the 90-lb force of figure shown below by a force through A and a couple whose forces act horizontally through points B and C.



3- Replace the 500-lb force of figure shown below by (a) a force through A and a couple; (b) a force through B and a couple.

