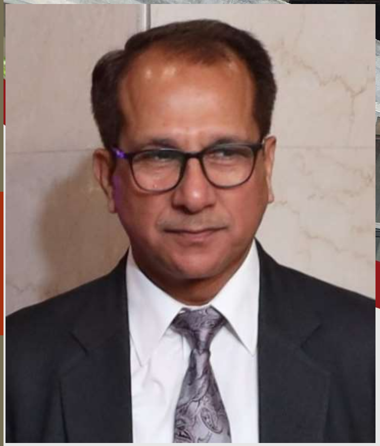
Moment of a Force



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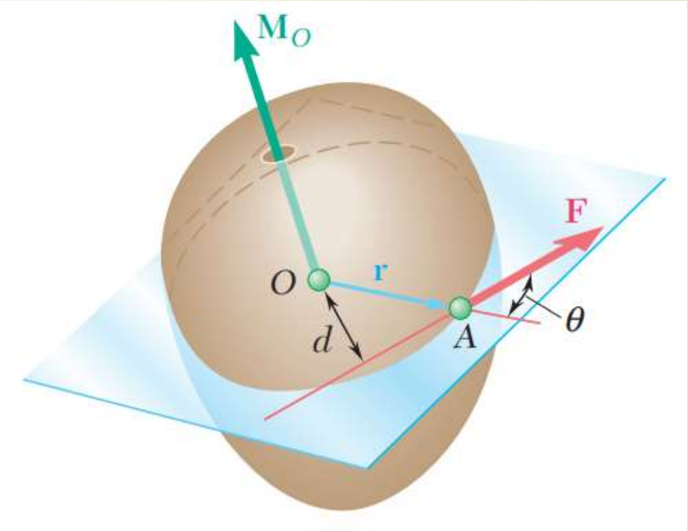
Moment of a Force about a Point or an Axis

Moment of a force about a point or an axis

Consider the force F, represented by a vector, the effect of the force on the rigid body depends also upon its point of application A. The position of A is defined by the vector r, which is the position vector of A.

The moment of the force F, about point O is the vector product of r and F.

$$\boxed{M_o = r \times F}$$



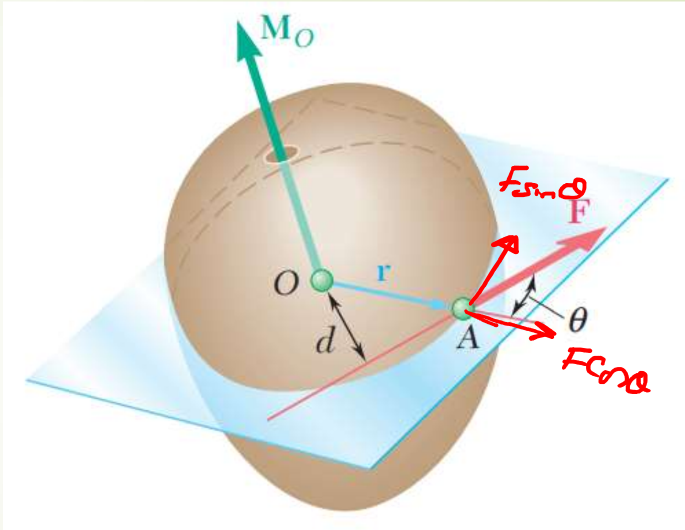
This rotation will be observed as counter-clockwise by an observer located at the tip of M_o

Moment of a force about a point or an axis

As θ is the angle between the lines of action of the position vector r and the force F,
The magnitude of the moment of F about O is

$$\boxed{M_o = rF \sin\theta = Fd}$$

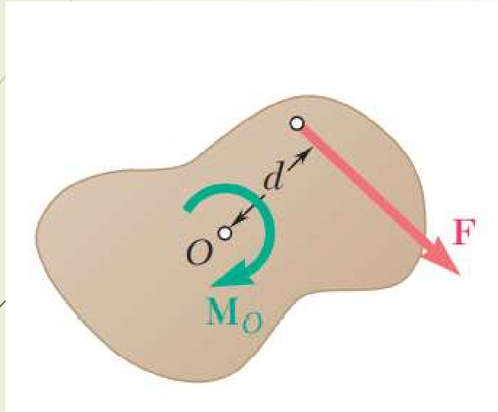
where d is the perpendicular distance from O to the line of action of force F.



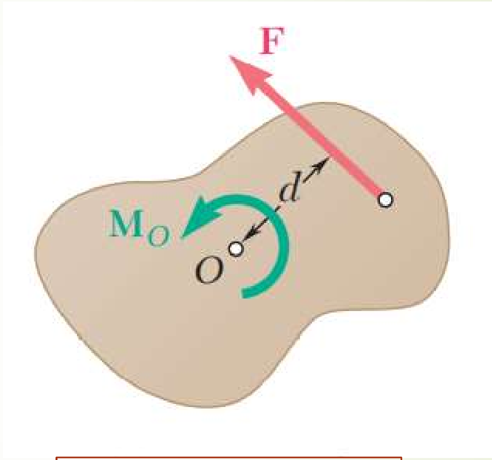
So, the tendency of a force F to make a rigid body rotate about a fixed axis perpendicular to the force is known as ***moment of a force*** or the ***moment***.

The magnitude of M_o depends upon the distance 'd' of F from that axis as well as upon the magnitude of F.

Clockwise and counter-clockwise moment



$$M_o = +Fd$$



$$M_o = -Fd$$

Varignon's Theorem

It states that the moment about a given point O of the resultant of several concurrent forces is equal to the sum of the moments of the various forces about the same point O.

$$r \times (F_1 + F_2 + \cdots\cdots) = r \times F_1 + r \times F_2 + \cdots\cdots$$

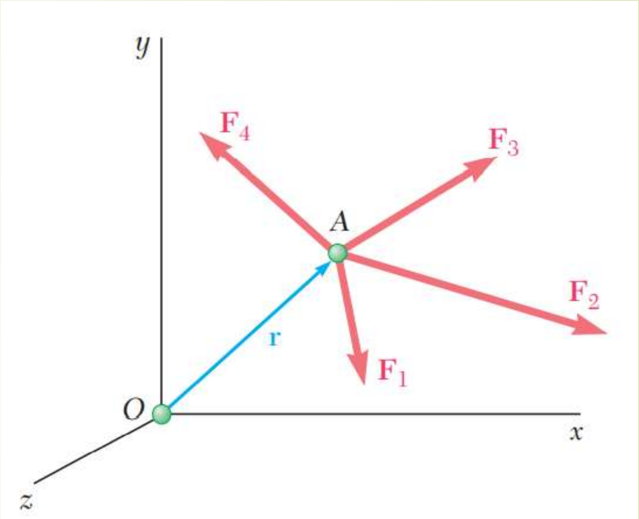
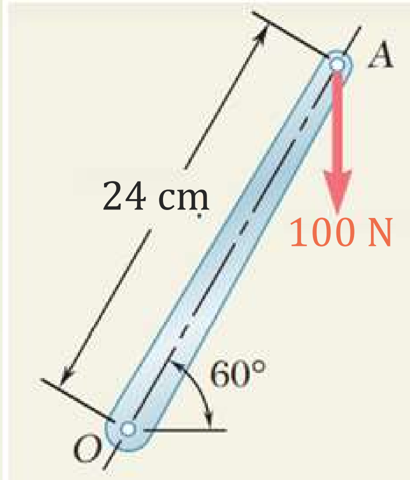


Illustration: A 100 N vertical force is applied to the end of a lever which is attached to a shaft at O. Determine (a) the moment of the 100 N force about O; (b) the horizontal force applied at A which creates the same moment about O; (c) the smallest force applied at A which creates the same moment about O; (d) how far from the shaft a 240 N vertical force must act to create the same moment about O.

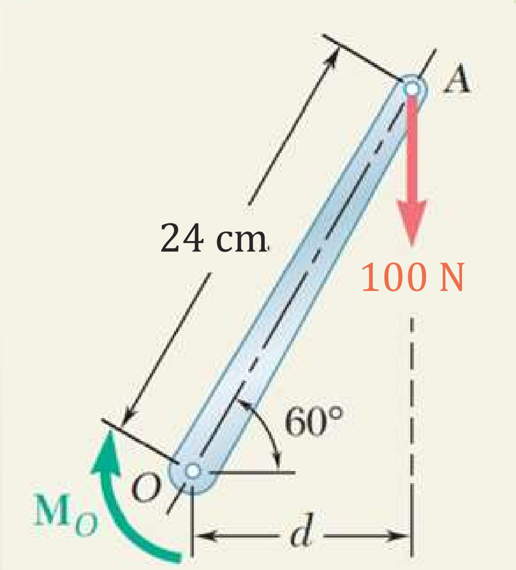


Solution: (a). The perpendicular distance from O to the line of action of force is

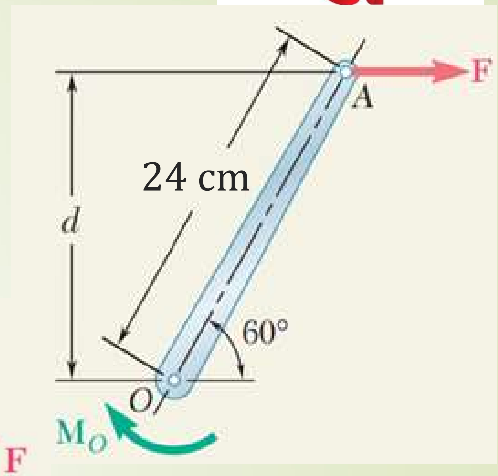
$$\boxed{d = 24\cos 60° = 12\ cm}$$

$$\boxed{M_o = 12 \times 100 = \mathbf{1200\ Ncm}}$$

The force will tend to rotate the lever in clockwise direction.



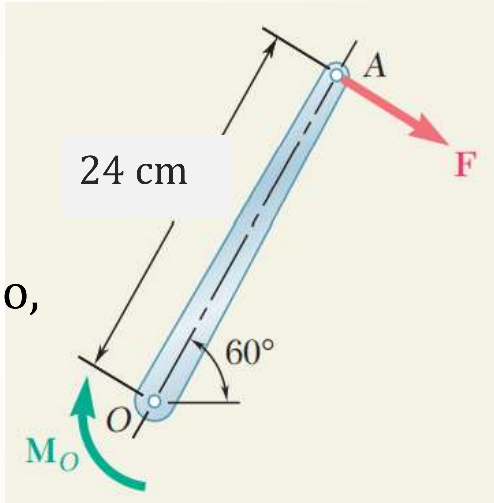
(b) the horizontal force applied at A which creates the same moment about O;
(c) the smallest force applied at A which creates the same moment about O;
(d) how far from the shaft a 240 N vertical force must act to create the same moment about O.



(b). The perpendicular distance from O to the line of action of force when it is horizontal

$$\boxed{d = 24 \sin 60° = 20.78\ cm}$$

$$\boxed{1200 = F \times 20.78 \rightarrow \boldsymbol{F = 57.75\ N}}$$



(c). Since $M_o = Fd$, F will be smallest if d is the largest , so,

$$\boxed{1200 = F \times 24 \rightarrow \boldsymbol{F = 50\ N}}$$

(d). $M_o = Fd,$ $\boxed{1200 = 240 \times d \rightarrow d = 5\ cm}$

$$\boxed{\text{The distance } \boldsymbol{OB} = \frac{5}{\cos 60°} = \mathbf{10\ cm}}$$

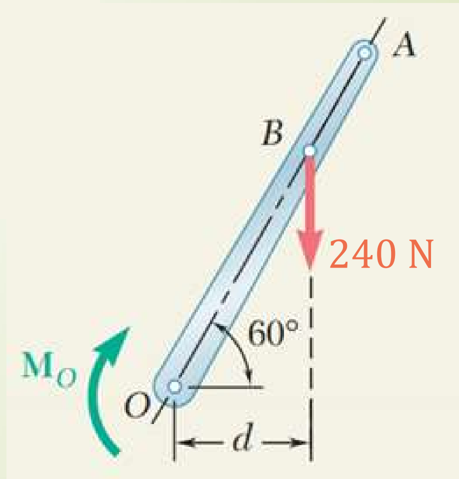
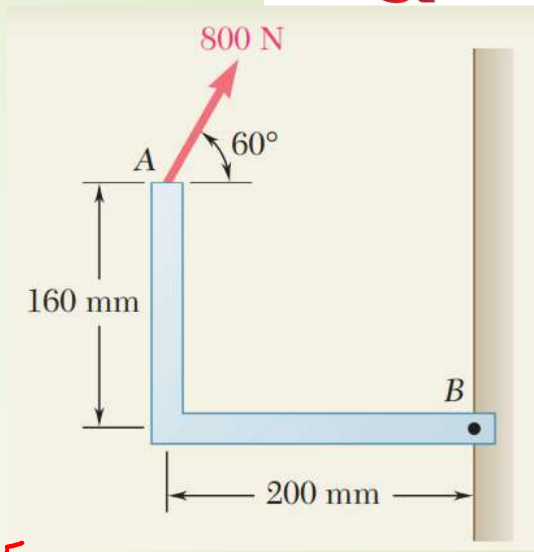
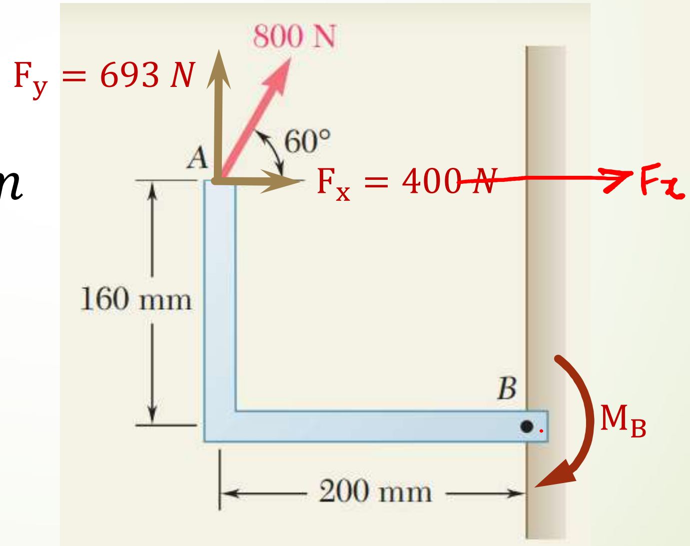


Illustration. A force of 800 N acts on a bracket as shown. Determine the moment of the force about *B.*



Solution: Resolve the force F into its rectangular components

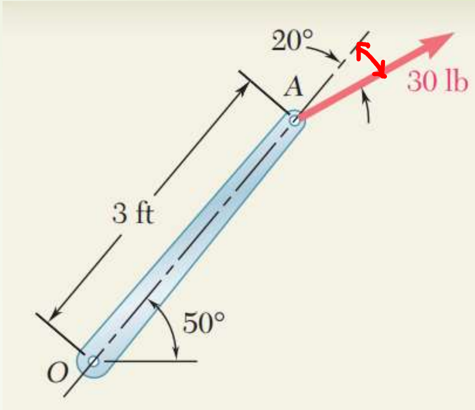


$$\Sigma M_B = (400 \times 0.16) + (693 \times 0.2)\ Nm$$

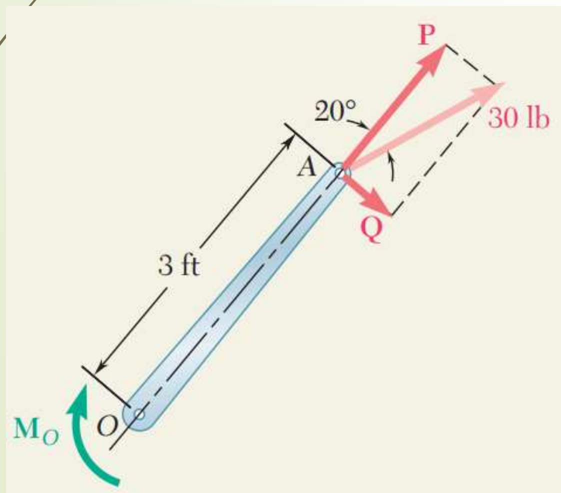
$$\mathbf{M_B = 202.6\ \mathit{Nm}}$$

The force will tend to rotate the lever in clockwise direction.

Illustration. A force of 30 lb acts on the end of the 3 ft long lever as shown. Determine the moment of the force about *O.*



Solution: The force is replaced by two components, one component P in the direction of OA and other component Q perpendicular to OA .



$$Q = 30 \sin 20° = 10.26\ lb$$

$$M_o = 10.26 \times 3 = 30.78\ lbft$$

THANK YOU

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