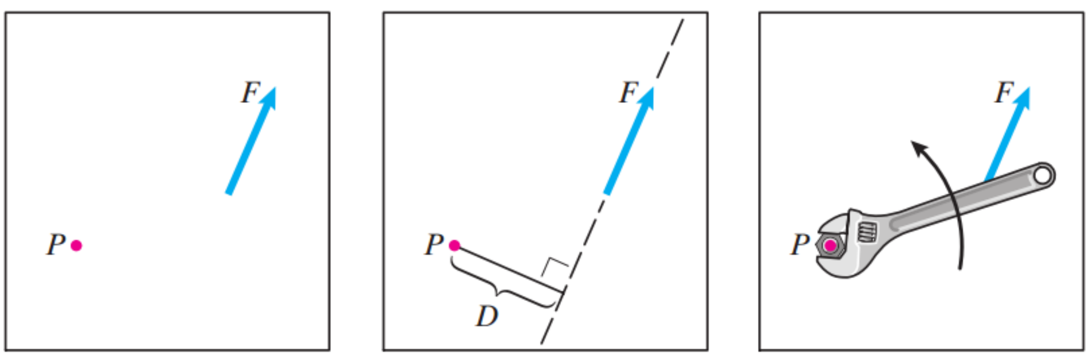
2.4.Moment of a force

Consider a force of magnitude F and a point P, and let's view them in the direction perpendicular to the plane containing the force vector and the point (Fig. a). The *magnitude of the moment* of the force about P is the product DF, where D is the perpendicular distance from P to the line of action of the force (Fig. b). In this example, the force would tend to cause counterclockwise rotation about point P. That is, if we imagine that the force acts on

an object that can rotate about point P, the force would cause counterclockwise rotation (Fig. c). We say that the *direction of the moment* is counterclockwise. *We define counterclockwise moments to be positive and clockwise moments to be negative*. (This is the usual convention, although we occasionally encounter situations in which it is more convenient to define clockwise moments to be positive.) Thus, the moment of the force about P is

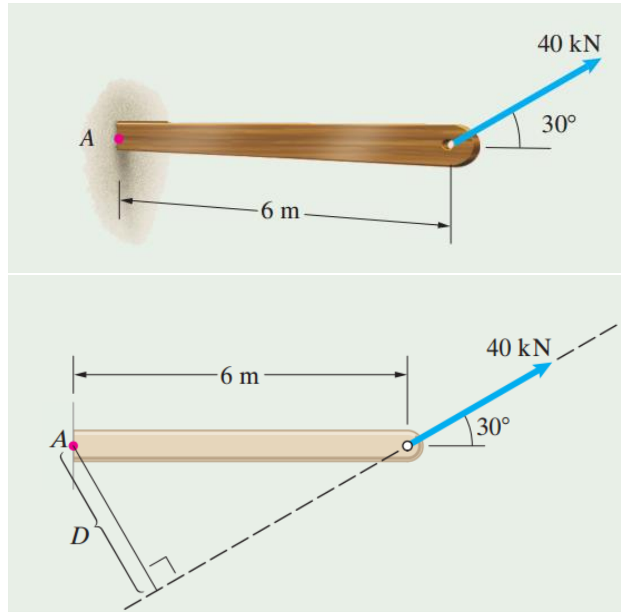
$$M_P = F * D$$



(a) (b) (c)

Example: what is the moment of the 40^{KN} about point A?

Solution:



The perpendicular distance from A to the line of action of the force is

$D = (6 \text{ m}) \sin 30° = 3 \text{ m}.$

Therefore the magnitude of the moment is

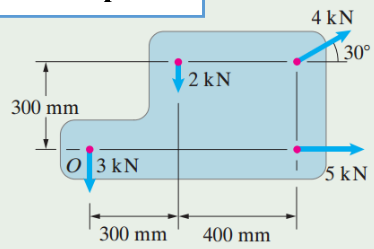
$(3 \text{ m})(40 \text{ kN}) = 120 \text{ kN-m}.$

The direction of the moment is counterclockwise, so

$M_A = 120 \text{ kN-m}.$

Practice Problem Resolve the 40-kN force into horizontal and vertical components and calculate the sum of the moments of the components about A.

Example:



Four forces act on the machine part. What is the sum of the moments of the forces about the origin O?

Strategy

We can determine the moments of the forces about point O directly from the given information except for the 4-kN force. We will determine its moment by expressing it in terms of components and summing the moments of the components.

Solution

Moment of the 3-kN Force The line of action of the 3-kN force passes through O. It exerts no moment about O.

Moment of the 5-kN Force The line of action of the 5-kN force also passes through O. It too exerts no moment about O.

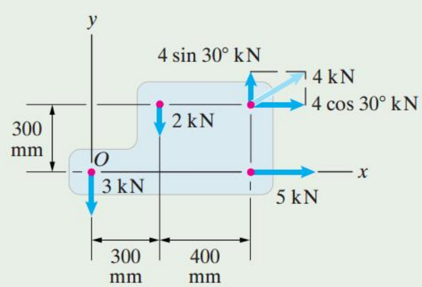
Moment of the 2-kN Force The perpendicular distance from O to the line of action of the 2-kN force is 0.3 m, and the direction of the moment about O is clockwise. The moment of the 2-kN force about O is

$$-(0.3 \text{ m})(2 \text{ kN}) = -0.600 \text{ kN-m}.$$

(Notice that we converted the perpendicular distance from millimeters into meters, obtaining the result in terms of kilonewton-meters.)

Moment of the 4-kN Force In Fig. a, we introduce a coordinate system and express the 4-kN force in terms of x and y components. The perpendicular distance from O to the line of action of the x component is 0.3 m, and the direction of the moment about O is clockwise. The moment of the x component about O is

$$-(0.3 \text{ m})(4 \cos 30° \text{ kN}) = -1.039 \text{ kN-m}.$$



(a) Resolving the 4-kN force into components.

The perpendicular distance from point O to the line of action of the y component is 0.7 m, and the direction of the moment about O is counterclockwise. The moment of the y component about O is

$$(0.7 \text{ m})(4 \sin 30° \text{ kN}) = 1.400 \text{ kN-m}.$$

The sum of the moments of the four forces about point O is

$$\Sigma M_0 = -0.600 - 1.039 + 1.400 = -0.239 \text{ kN-m}.$$

The four forces exert a 0.239 kN-m clockwise moment about point O.

3. Chapter Three: Equilibrium for a Rigid Body

The objectives of this chapter are:

- ✓ To develop the equations of equilibrium for a rigid body.
- ✓ To introduce the concept of the free-body diagram for a rigid body.
- ✓ To show how to solve rigid-body equilibrium problems using the equations of equilibrium.

3.1. Conditions for Rigid-Body Equilibrium

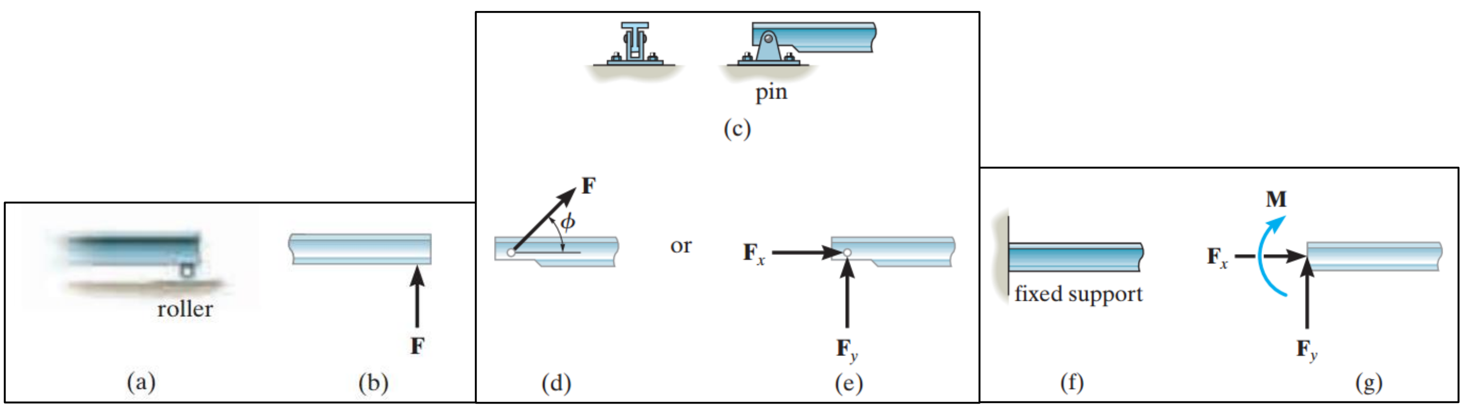
The body is said to be in ***equilibrium*** when resultant force and couple moment are both equal to zero. Mathematically, the equilibrium of a body is expressed as:

$$\sum Fx = 0$$

$$\sum Fy = 0$$

$$\sum M = 0$$

Main Support Reactions



Roller Pin (hinge) Fixed