2/4 Moment

In addition to the tendency to move a body in the direction of its application, a force can also tend to rotate a body about an axis. The axis may be any line which neither intersects nor is parallel to the line of action of the force. This rotational tendency is known as the *moment* **M** of the force. Moment is also referred to as *torque*.

As a familiar example of the concept of moment, consider the pipe wrench of Fig. 2/8*a*. One effect of the force applied perpendicular to the handle of the wrench is the tendency to rotate the pipe about its vertical axis. The magnitude of this tendency depends on both the magnitude F of the force and the effective length d of the wrench handle. Common experience shows that a pull which is not perpendicular to the wrench handle is less effective than the right-angle pull shown.

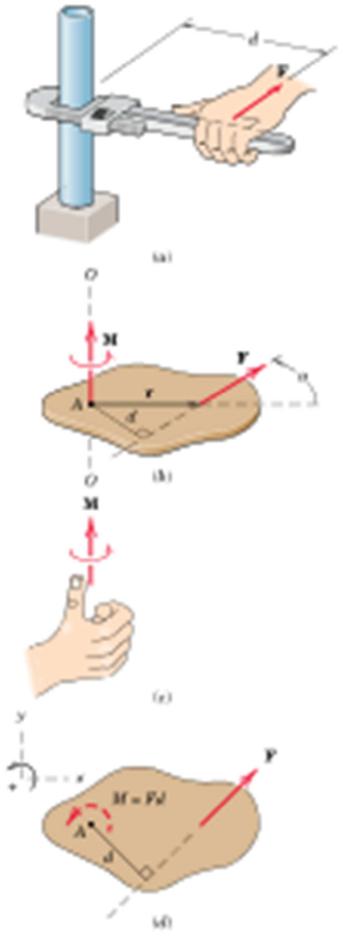


Figure 2/8

Moment about a Point

Figure 2/8*b* shows a two-dimensional body acted on by a force **F** in its plane. The magnitude of the moment or tendency of the force to rotate the body about the axis *O-O* perpendicular to the plane of the body is proportional both to the magnitude of the force and to the *moment arm* d, which is the perpendicular distance from the axis to the line of action of the force. Therefore, the magnitude of the moment is defined as

$$\boxed{M = Fd} \tag{2/5}$$

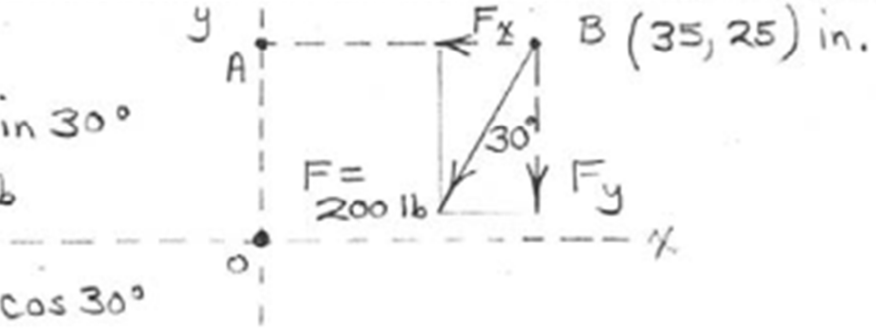
The moment is a vector **M** perpendicular to the plane of the body. The sense of **M** depends on the direction in which **F** tends to rotate the body. The right-hand rule, Fig. 2/8*c*, is used to identify this sense. We represent the moment of **F** about *O-O* as a vector pointing in the direction of the thumb, with the fingers curled in the direction of the rotational tendency.

The moment **M** obeys all the rules of vector combination and may be considered a sliding vector with a line of action coinciding with the moment axis. The basic units of moment in SI units are newton-meters (N·m), and in the U.S. customary system are pound-feet (lb-ft).

When dealing with forces which all act in a given plane, we customarily speak of the moment *about a point*. By this we mean the moment with respect to an axis normal to the plane and passing through the point. Thus, the moment of force **F** about point A in Fig. 2/8*d* has the magnitude $M = Fd$ and is counterclockwise.

Moment directions may be accounted for by using a stated sign convention, such as a plus sign (+) for counterclockwise moments and a minus sign (−) for clockwise moments, or vice versa. Sign consistency within a given problem is essential. For the sign convention of Fig. 2/8*d*, the moment of **F** about point A (or about the z-axis passing through point A) is positive. The curved arrow of the figure is a convenient way to represent moments in two-dimensional analysis.

2/30



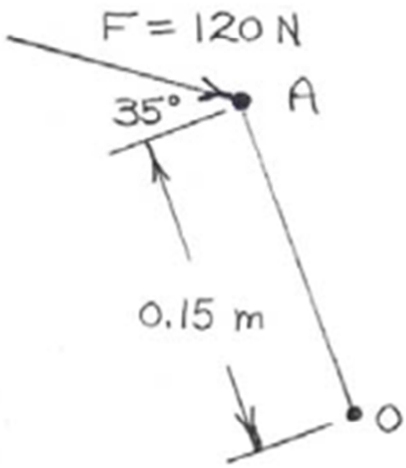
$$|F_x| = 200 \sin 30° = 100 \text{ lb}$$

$$|F_y| = 200 \cos 30° = 173.2 \text{ lb}$$

$$+\circlearrowright M_A = 173.2(35) = \underline{6060 \text{ lb-in. } (505 \text{ lb-ft}) \text{ CW}}$$

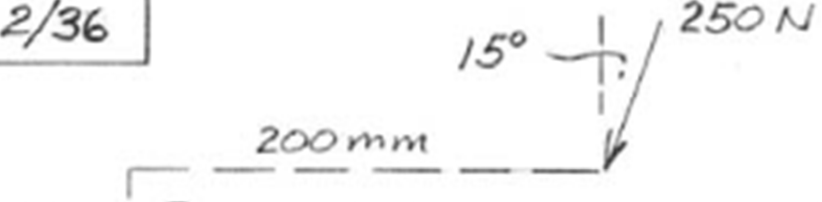
$$+\circlearrowright M_O = 173.2(35) - 100(25) = \underline{3560 \text{ lb-in. } (297 \text{ lb-ft}) \text{ CW}}$$

2/33



$$+\circlearrowright M_O = 120 \cos 35° (0.15) = \underline{14.74 \text{ N·m CW}}$$

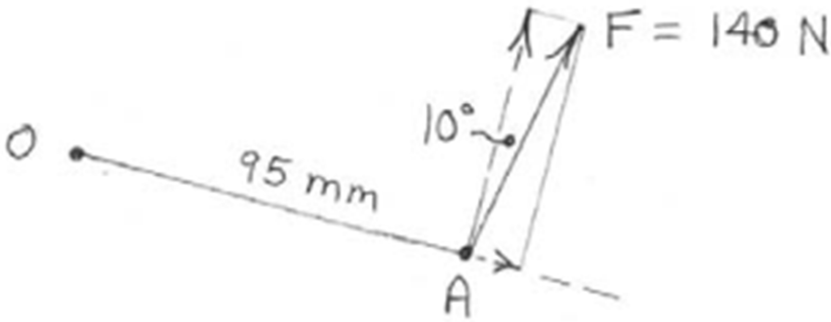
2/36



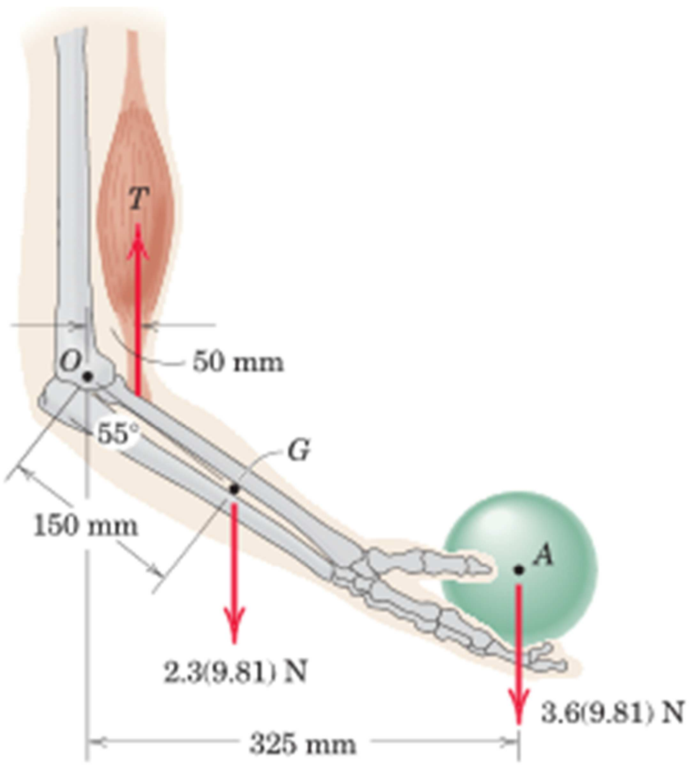
$$\circlearrowright^{+} M_O = 250\cos 15°(0.200) - 250\sin 15°(0.030)$$

$$= 48.30 - 1.941 = \underline{46.4\ \text{N}\cdot\text{m}}$$

2/37

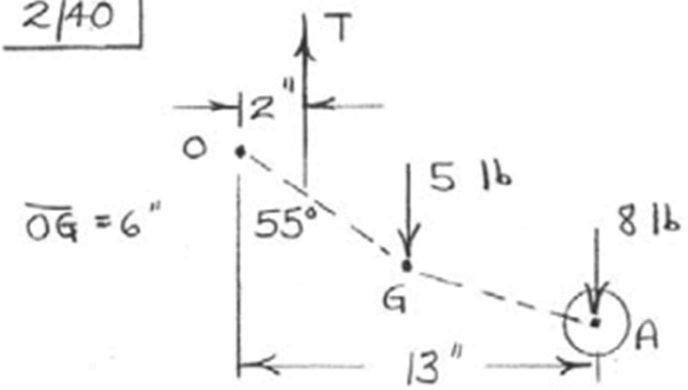


$$\circlearrowleft^{+} M_O = (140\cos 10°)(0.095) = \underline{13.10\ \text{N}\cdot\text{m}\ \ \text{CCW}}$$



Problem 2/40

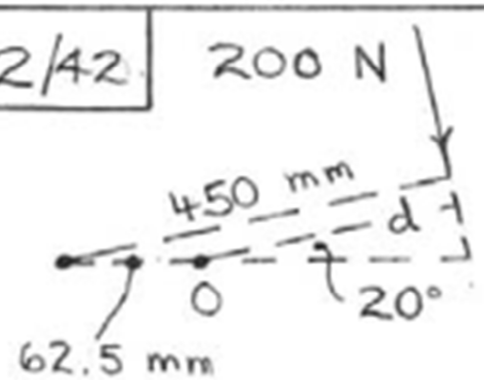
2/40



The combined moment about O of the 5-lb and 8-lb weights is

$+\circlearrowright M_O = 5\,(6 \sin 55°) + 8(13) = 128.6$ lb-in.

2/42



$d = 450 - 62.5 \cos 20° = 391$ mm

$+\circlearrowright M = Fd = 200(0.391) = \underline{78.3 \text{ N}\cdot\text{m}}$