CHAPTER 9 | ROTATIONAL DYNAMICS

CONCEPTUAL QUESTIONS

10. **REASONING AND SOLUTION**
    Treating the wine rack and the bottle as a rigid body, the two external forces that keep it in equilibrium are its weight, \( m g \), located at the center of gravity, and the normal force, \( F_N \), exerted on the base by the table.

    Note that the weight acts at the center of gravity (CG), which must be located exactly above the point where the normal force acts, as is the case in Figure 9.10c.

14. **REASONING AND SOLUTION** When you are lying down with your hands behind your head, your moment of inertia \( I \) about your stomach is greater than it is when your hands are on your stomach. Sit-ups are then more difficult because, with a greater \( I \), you must exert a greater torque about your stomach to give your upper torso the same angular acceleration, according to Equation 9.7.

CHAPTER 9 | ROTATIONAL DYNAMICS

PROBLEMS

3. **REASONING AND SOLUTION** The torque about the center of the cable car is \( \tau = FL \), where \( L \) is the lever arm.

\[
\tau = FL = 2(185 \text{ N})(4.60 \text{ m}) = 1.70 \times 10^3 \text{ N} \cdot \text{m}
\]

14. **REASONING** When the board just begins to tip, three forces act on the board. They are the weight \( W \) of the board, the weight \( W_p \) of the person, and the force \( F \) exerted by the right support.

Since the board will rotate around the right support, the lever arm for this force is zero, and the torque exerted by the right support is zero. The lever arm for the weight of the board is equal to one-half the length of the board minus the overhang length: \( 2.5 \text{ m} - 1.1 \text{ m} = 1.4 \text{ m} \).
The lever arm for the weight of the person is \( x \). Therefore, taking counterclockwise torques as positive, we have

\[-W_p x + W(1.4 \text{ m}) = 0\]

This expression can be solved for \( x \).

**SOLUTION** Solving the expression above for \( x \), we obtain

\[ x = \frac{W(1.4 \text{ m})}{W_p} = \frac{(225 \text{ N})(1.4 \text{ m})}{450 \text{ N}} = 0.70 \text{ m} \]

16. **REASONING AND SOLUTION** The net torque about an axis through the contact point between the tray and the thumb is

\[ \Sigma \tau = F(0.0400 \text{ m}) - (0.250 \text{ kg})(9.80 \text{ m/s}^2)(0.320 \text{ m}) - (1.00 \text{ kg})(9.80 \text{ m/s}^2)(0.180 \text{ m}) - (0.200 \text{ kg})(9.80 \text{ m/s}^2)(0.140 \text{ m}) = 0 \]

\[ F = 70.6 \text{ N, up} \]

Similarly, the net torque about an axis through the point of contact between the tray and the finger is

\[ \Sigma \tau = T(0.0400 \text{ m}) - (0.250 \text{ kg})(9.80 \text{ m/s}^2)(0.280 \text{ m}) - (1.00 \text{ kg})(9.80 \text{ m/s}^2)(0.140 \text{ m}) - (0.200 \text{ kg})(9.80 \text{ m/s}^2)(0.100 \text{ m}) = 0 \]

\[ T = 56.4 \text{ N, down} \]