Answer to Essential Question 10.12: Adding the two expressions for the support forces gives:

$$F_A + F_B = 560\text{ N} - 320d\text{ N/m} + 160\text{ N} + 320d\text{ N/m} = 720\text{ N}.$$

In other words, when the system is in equilibrium the sum of the support forces is always 720 N. This is expected because the supports combine to balance the weight of the system. Your weight of 480 N and the board's weight of 240 N add to 720 N.

Chapter Summary

Essential Idea for Rotational Motion

The methods we applied previously to solve straight-line motion problems, such as using constant-acceleration equations and Newton's Laws of Motion, can essentially be adapted to help us analyze situations involving rotational motion.

Rotational Kinematics

To help us understand how things move we defined the straight-line motion variables of position, displacement, velocity, and acceleration. The analogous rotational variables help us understand rotational motion.

Straight-line motion variable	**Analogous rotational motion variable**	**Connection**
Displacement, $\Delta\vec{s}$	Angular displacement, $\Delta\vec{\theta}$	$\Delta s = r\,\Delta\theta$
Velocity, $\vec{v} = \dfrac{\Delta\vec{s}}{\Delta t}$	Angular velocity, $\vec{\omega} = \dfrac{\Delta\vec{\theta}}{\Delta t}$	$v_T = r\omega$
Acceleration, $\vec{a} = \dfrac{\Delta\vec{v}}{\Delta t}$	Angular acceleration, $\vec{\alpha} = \dfrac{\Delta\vec{\omega}}{\Delta t}$	$a_T = r\alpha$

Table 10.2: Connecting straight-line motion variables to rotational variables. To prevent confusion with *r*, the radius, the variable $\vec{s}$ is used to represent position. The T subscripts denote tangential, for components that are tangential to the circular path.

In the special case of one-dimensional motion with constant acceleration, we derived a set of useful equations. An analogous set applies to rotation with constant angular acceleration.

Straight-line motion equation	**Analogous rotational motion equation**
$v = v_i + a\,t$ (Equation 2.9)	$\omega = \omega_i + \alpha\,t$ (Equation 10.6)
$x = x_i + v_i\,t + \frac{1}{2}a\,t^2$ (Equation 2.11)	$\theta = \theta_i + \omega_i\,t + \frac{1}{2}\alpha\,t^2$ (Equation 10.7)
$v^2 = v_i^2 + 2a\,\Delta x$ (Equation 2.12)	$\omega^2 = \omega_i^2 + 2\alpha\,\Delta\theta$ (Equation 10.8)

Table 10.1: Comparing the one-dimensional kinematics equations from chapter 2 to the rotational motion equations that can be applied to rotating objects.

Static Equilibrium

An object is in static equilibrium when it remains at rest. Two conditions apply to objects in static equilibrium. These are:

$$\sum \vec{F} = 0 \qquad \text{and} \qquad \sum \vec{\tau} = 0 .$$

Expressed in words, an object in static equilibrium experiences no net force and no net torque.

A General Method for Solving a Static Equilibrium Problem

1. Draw a diagram of the situation.
2. Draw a free-body diagram showing all the forces acting on the object.
3. Choose a rotational coordinate system. Pick an appropriate axis to take torques about, and then apply Newton's Second Law for Rotation ($\sum \vec{\tau} = 0$) to obtain one or more torque equations.
4. If necessary, choose an appropriate *x*-*y* coordinate system for forces. Apply Newton's Second Law ($\sum \vec{F} = 0$) to obtain one or more force equations.
5. Combine the resulting equations to solve the problem.

Rotational Dynamics

Mass is our measure of inertia for straight-line motion, while rotational inertia depends on the mass, the way the mass is distributed, and the axis about which rotation occurs. Torque is the rotational equivalent of force. The concepts of mass, force, and acceleration are linked by Newton's Second Law; an analogous law links the concepts of rotational inertia, torque, and angular acceleration.

Straight-line motion concept	**Analogous rotational motion concept**	**Connection**
Inertia: mass, *m*	Rotational Inertia, $I = cMR^2$ (*c* depends on axis and object's shape)	$I = \sum m_i r_i^2$
Can change motion: Force, $\vec{F}$	Can change rotation: Torque, $\vec{\tau}$	$\tau = r F \sin\theta$
Newton's Second Law, $\sum \vec{F} = m\vec{a}$	Second Law for Rotation, $\sum \vec{\tau} = I\vec{\alpha}$	Same form

Table 10.5: Rotational dynamics is governed by concepts that are similar to those that govern dynamics in straight-line motion.