PROBLEM SOLVING Statics

1. Choose one object at a time for consideration. Make a careful **free-body diagram** by showing all the forces acting on that object and the points at which these forces act. If you aren't sure of the direction of a force, choose a direction; if the actual direction is opposite, your eventual calculation will give a result with a minus sign.
2. Choose a convenient **coordinate system**, and resolve the forces into their components.
3. Using letters to represent unknowns, write down the **equilibrium equations** for the **forces**:
$$\Sigma F_x = 0 \quad \text{and} \quad \Sigma F_y = 0,$$
assuming all the forces act in a plane.
4. For the **torque equation**,
$$\Sigma \tau = 0,$$
choose any axis perpendicular to the xy plane that might make the calculation easier. (For example, you can reduce the number of unknowns in the resulting equation by choosing the axis so that one of the unknown forces acts through that axis; then this force will have zero lever arm and produce zero torque, and so won't appear in the equation.) Pay careful attention to determining the lever arm for each force correctly. Give each torque a + or − sign to indicate torque direction. For example, if torques tending to rotate the object counterclockwise are positive, then those tending to rotate it clockwise are negative.
5. **Solve** these equations for the unknowns. Three equations allow a maximum of three unknowns to be solved for. They can be forces, distances, or even angles.

PHYSICS APPLIED
Balancing a seesaw

EXAMPLE 9–4 Balancing a seesaw. A board of mass $M = 2.0\,\text{kg}$ serves as a seesaw for two children, as shown in Fig. 9–7a. Child A has a mass of 30 kg and sits 2.5 m from the pivot point, P (his center of gravity is 2.5 m from the pivot). At what distance x from the pivot must child B, of mass 25 kg, place herself to balance the seesaw? Assume the board is uniform and centered over the pivot.

APPROACH We follow the steps of the Problem Solving Box explicitly.

SOLUTION

1. **Free-body diagram**. We choose the board as our object, and assume it is horizontal. Its free-body diagram is shown in Fig. 9–7b. The forces acting on the board are the forces exerted downward on it by each child, $\vec{\mathbf{F}}_A$ and $\vec{\mathbf{F}}_B$, the upward force exerted by the pivot $\vec{\mathbf{F}}_N$, and the force of gravity on the board ($= Mg$) which acts at the center of the uniform board.
2. **Coordinate system**. We choose y to be vertical, with positive upward, and x horizontal to the right, with origin at the pivot.
3. **Force equation**. All the forces are in the y (vertical) direction, so
$$\Sigma F_y = 0$$
$$F_N - m_A g - m_B g - Mg = 0,$$
where $F_A = m_A g$ and $F_B = m_B g$ because each child is in equilibrium when the seesaw is balanced.

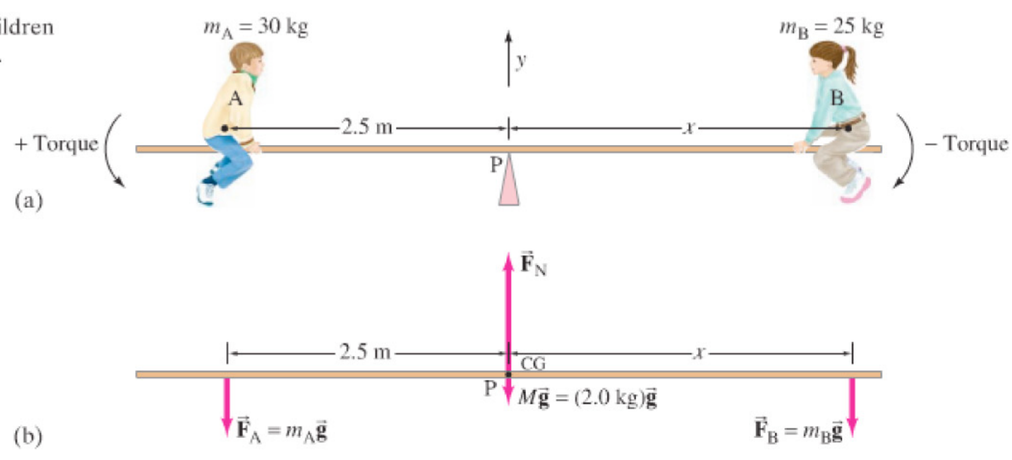

FIGURE 9–7 (a) Two children on a seesaw, Example 9–4. (b) Free-body diagram of the board.