The lever arm for the bridge's weight (d_b) is the distance from the bridge's center of mass to the pivot point, or half the bridge's length. The lever arm for the polar bear is two-thirds the bridge's length. The lever arm for the normal force farthest from the pivot equals the entire length of the bridge.

$$d_b = \tfrac{1}{2}L, \qquad d_p = \tfrac{2}{3}L, \qquad d_2 = L$$

The torque equation thus takes the following form:

$$\tau_{net} = -\frac{(m_b g)L}{2} - \frac{2(m_b g)L}{3} + F_{n,2}L$$

3. CALCULATE **Substitute the values into the equation(s) and solve:**

$$\tau_{net} = -\tfrac{1}{2}(2.50 \times 10^2 \text{ kg})(9.81 \text{ m/s}^2)(12.0 \text{ m})$$
$$-\tfrac{2}{3}(9.00 \times 10^2 \text{ kg})(9.81 \text{ m/s}^2)(12.0 \text{ m}) + F_{n,2}(12.0 \text{ m}) = 0$$

$$F_{n,2}(12.0 \text{ m}) = (1.47 \times 10^4 \text{ N}\bullet\text{m}) + (7.06 \times 10^4 \text{ N}\bullet\text{m})$$
$$= 8.53 \times 10^4 \text{ N}\bullet\text{m}$$
$$F_{n,2} = 7.11 \times 10^3 \text{ N}$$

Now use this value in the first condition equation to find $F_{n,1}$.

$$F_y = F_{n,1} + (7.11 \times 10^3 \text{ N}) - (2.50 \times 10^2 \text{ kg})(9.81 \text{ m/s}^2)$$
$$-(9.00 \times 10^2 \text{ kg})(9.81 \text{ m/s}^2) = 0$$

$$F_{n,1} = \boxed{4.17 \times 10^3 \text{ N}}$$

4. EVALUATE The sum of the upward normal forces exerted on the ends of the bridge must equal the weight of the polar bear and the bridge. (The individual normal forces change as the polar bear moves across the bridge.)

$$(4.17 \text{ kN} + 7.11 \text{ kN}) = (2.50 \times 10^2 \text{ kg} + 9.00 \times 10^2 \text{ kg})(9.81 \text{ m/s}^2)$$
$$11.28 \text{ kN} = 11.28 \times 10^3 \text{ N}$$

ADDITIONAL PRACTICE

1. The Galápagos fur seals are very small; an average adult male has a mass of 64 kg, and a female has a mass of only 27 kg. Suppose one average adult male seal and one average adult female seal sit on opposite ends of a light board that has a length of 3.0 m. How far from the male seal should the board be pivoted in order for equilibrium to be maintained?

2. The heaviest sea sponge ever collected had a mass of 40.0 kg, but after drying out, its mass decreased to 5.4 kg. Suppose that two loads equal to the wet and dry masses of this giant sponge hang from the opposite ends of a horizontal meterstick of negligible mass and that a fulcrum is placed 70.0 cm from the larger of the two masses. How much extra force must be applied to the end of the meterstick with the smaller mass in order to provide equilibrium?