In the figure below right, a 15.0 kg block is held in place via a pulley system. The person's upper arm is vertical; the forearm makes angle $\theta = 25^\circ$ with the horizontal. Forearm and hand together have a mass of 2.50 kg, with a center of mass at distance $d_1 = 18.0$ cm from the contact point of the forearm bone and the upper-arm bone (humerus). The triceps muscle pulls vertically upward on the forearm at distance $d_2 = 2.00$ cm behind that contact point. Distance $d_3$ is 40.0 cm. Take the upward direction to be positive.

a) What is the force on the forearm from the triceps muscle?

Since the block is in equilibrium, the tension in the string is equal to the gravitational force $Mg$ on the block. Therefore, the force exerted at the person's hand is $Mg$ and it is directed upward. We take counterclockwise as positive. The balance of torques equation around the contact point yields

$$-F_t d_2 \cos \theta - mg d_1 \cos \theta + Mgd_3 \cos \theta = 0$$

$$\Rightarrow F_t = \frac{Mgd_3 - mgd_1}{d_2} = 2720 \text{ N},$$

where $m$ is the mass of the forearm. The force is directed upward.

b) What is the force on the forearm from the humerus?

We take our positive direction upward. The balance of forces equation yields

$$Mg + F_t - F_h - mg = 0 \Rightarrow F_h = mg - Mg - F_t = -2840 \text{ N}$$

The negative sign indicates it is directed downward.