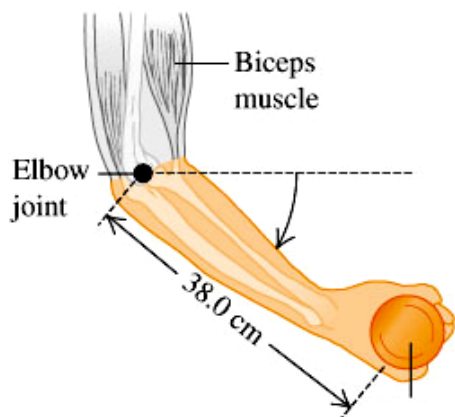


# Physics 180A Chapter 10 Problem 52

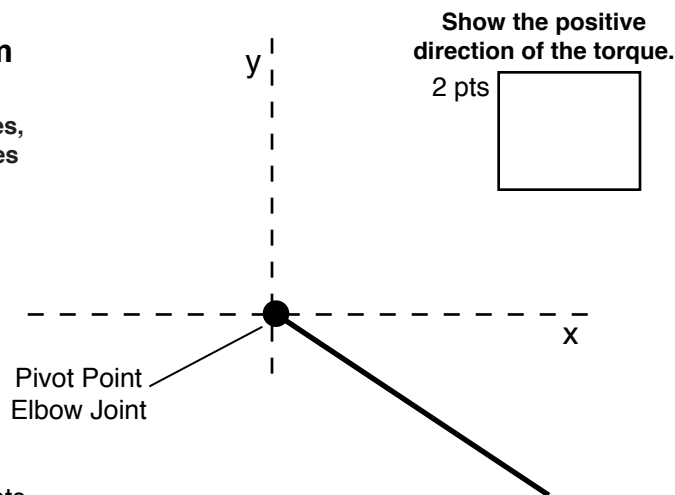
A 72.0 kg weight lifter is doing arm raises using a 7.50 kg weight in her hand. Her arm pivots around the elbow joint, starting 40.0° below the horizontal. Biometric measurements have shown that both forearms and the hands together account for 6.00 % of a person's weight. Since the upper arm is held vertically, the biceps muscle always acts vertically and is attached to the bones of the forearm 5.50 cm from the elbow joint. The center of mass of this person's forearm-hand combination is 16.0 cm from the elbow joint, along the bones of the forearm, and the weight is held 38.0 cm from the elbow joint. What force does the biceps muscle exert on the forearm? Find the magnitude and direction of the force that the elbow joint exerts on the forearm.



## FreeBody Diagram

Draw the Freebody diagram include all forces, components of the forces and distances.

10 pts



## Sum of Forces

$$\Sigma F_x = F_{Ex} = ma = 0$$

$$\Sigma F_y = -F_{Ey} + F_{BM} - F_{FA} - F_W = ma = 0$$

What is the equation for Torque? 2 pts

 2 pts

Provide the Torques in symbolic form, no numbers!

$$\Sigma \tau =$$

 4 pts

Why are the Forces and Torques equal to zero? 2 pts

a. What force does the biceps muscle exert on the forearm?

## Sum of Torques

Solve symbolically for the Force due to the Bicep Muscle

Symbolically

$$F_{BM} =$$
 2 pts

Plug numbers in and solve numerically Answer 2 pts

$$F_{BM} =$$
 =

b. Find the magnitude and direction of the force that the elbow joint exerts on the forearm.

## Sum of Forces

$$F_{Ex} = 0 \text{ no force in the x-direction}$$

$$-F_{Ey} + F_{BM} - F_{FA} - F_W = 0$$

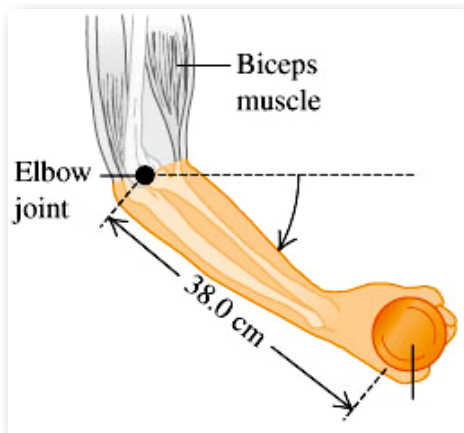
Plug numbers in for elbow Force and solve numerically

 2 pts

$$F_{Ey} =$$
 Answer 2 pts

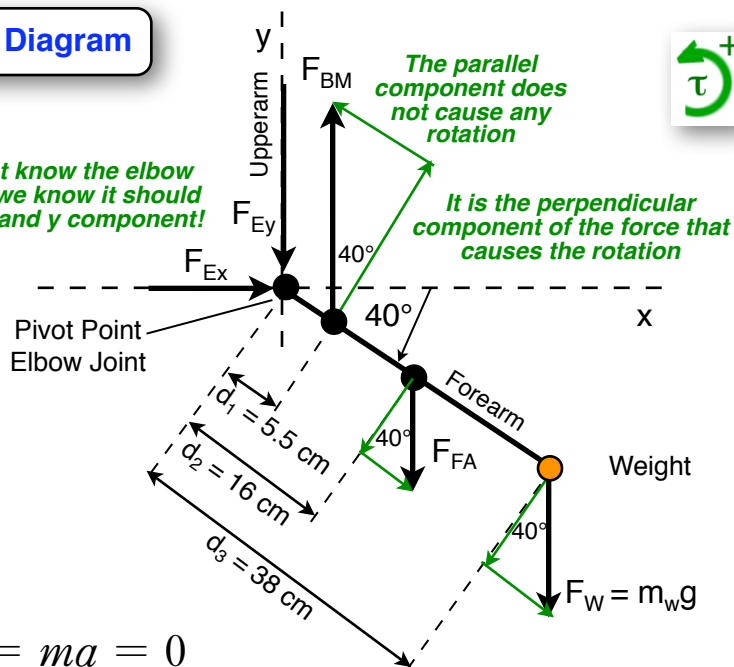
## Physics 180A Chapter 10 Problem 52

A 72.0 kg weight lifter is doing arm raises using a 7.50 kg weight in her hand. Her arm pivots around the elbow joint, starting 40.0° below the horizontal. Biometric measurements have shown that both forearms and the hands together account for 6.00 % of a person's weight. Since the upper arm is held vertically, the biceps muscle always acts vertically and is attached to the bones of the forearm 5.50 cm from the elbow joint. The center of mass of this person's forearm-hand combination is 16.0 cm from the elbow joint, along the bones of the forearm, and the weight is held 38.0 cm from the elbow joint. What force does the biceps muscle exert on the forearm? Find the magnitude and direction of the force that the elbow joint exerts on the forearm.



### FreeBody Diagram

We do not know the elbow force but we know it should have an x and y component!



### Sum of Forces

Static Equilibrium

$$\Sigma F_x = F_{Ex} = ma = 0 = ?$$

$$\Sigma F_y = -F_{Ey} + F_{BM} - F_{FA} - F_W = ma = 0$$

### Sum of Torques

$$\tau = F_{\perp} d$$

Static Equilibrium

$$\Sigma \tau = F_{BM} d_1 \cos \theta - F_{FA} d_2 \cos \theta - F_W d_3 \cos \theta = I\alpha = 0$$

No torques on Elbow forces since they are acting on the pivot point.

a. What force does the biceps muscle exert on the forearm?

### Sum of Torques

$$F_{BM} d_1 \cos \theta - F_{FA} d_2 \cos \theta - F_W d_3 \cos \theta = 0$$

$$F_{BM} d_1 \cos \theta = F_{FA} d_2 \cos \theta + F_W d_3 \cos \theta$$

The cosine of the angle cancels in all terms.

$$F_{BM} = \frac{F_{FA} d_2 + F_W d_3}{d_1}$$

$$F_{BM} = \frac{0.5(0.06)72kg(0.16m) + 7.5kg(9.8m/s^2)0.38m}{0.055m}$$

$$F_{BM} = 570N \text{ upwards !!!}$$

To keep the forearm stationary your Bicep Muscle needs to provide a lot of force since it is applied so close to the pivot point.

b. Find the magnitude and direction of the force that the elbow joint exerts on the forearm.

### Sum of Forces

$$F_{Ex} = 0 \quad \text{no force in the x-direction}$$

$$-F_{Ey} + F_{BM} - F_{FA} - F_W = 0$$

$$F_{Ey} = F_{BM} - F_{FA} - F_W$$

$$F_{Ey} = 570N - 2.16kg(9.8m/s^2) - 7.50kg(9.8m/s^2)$$

$$F_{Ey} = 475 N \text{ downwards}$$

This amount of force is necessary to keep the forearm stationary.