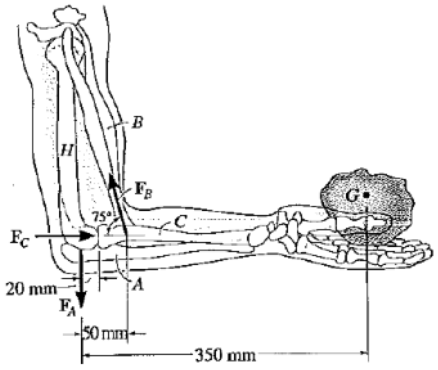
Equilibrium Rigid Body (Solution)

4-2. When holding the 20-N (≈ 2-kg) stone in equilibrium, the humerus H, assumed to be smooth, exerts normal forces $\mathbf{F}_C$ and $\mathbf{F}_A$ on the radius C and ulna A as shown. Determine these forces and the force $\mathbf{F}_B$ that the biceps B exerts on the radius for equilibrium. The stone has a center of mass at G. Neglect the weight of the arm.



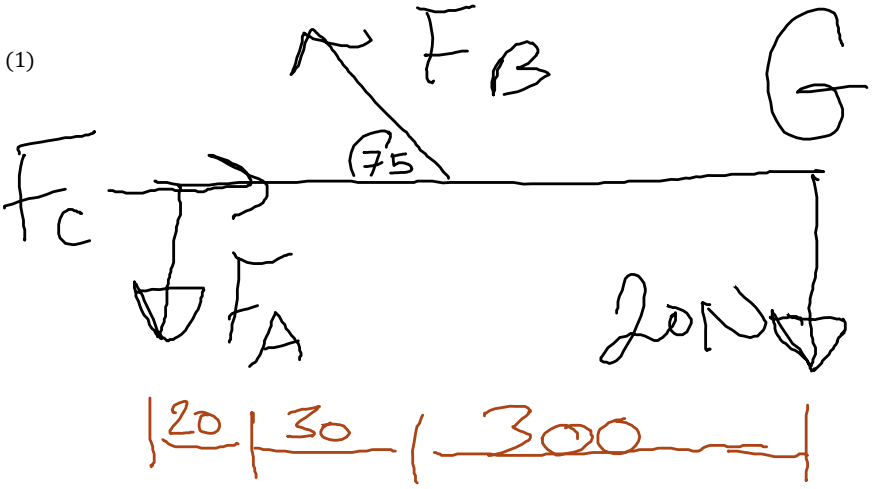
Q4-2 from Statics & Mechanics of Materials 2e by Hibbeler

Why: Need to solve for the forces to make sure you don't break your arm.

Steps:

1. FBD
2. Equation for forces/moments
3. Solve for forces

(1)



(2) $\sum F_x = F_C - F_B\cos(75) = 0$

$\sum F_y = F_B\sin(75) - F_A - 20 = 0$

$\sum M_B = 50F_A - (350-50)20 = 0$

(3) $50F_A - (350-50)20 = 0$

$F_A = \dfrac{(350-50)(20)}{50} 120\ N$

$F_B\sin(75) - F_A - 20 = 0$

$F_B = \dfrac{20+120}{\sin(75)} = 11.94\ N$

$F_C - F_B\cos(75) = 0$

$F_C = F_B\cos(75) = 37.51\ N$

$F_A = 120\ N$

$F_B = 144.94\ N$

$F_C = 37.51\ N$

Alternative solution taking the moment at H/C connection:

(3) $F_A = F_B\sin(75) - 20$

(2) $\sum F_x = F_C - F_B\cos(75) = 0$

$\sum F_y = F_B\sin(75) - F_A - 20 = 0$

$\sum M_A = 20F_A - (350-20)20 + 30F_B\sin(75) = 0$

$20\big(F_B\sin(75) - 20\big) - (350-20)20 + 30F_B\sin(75) = 0$

$20F_B\sin(75) - 400 - 6600 + 30F_B\sin(75) = 0$

$20F_B\sin(75) + 30F_B\sin(75) = 7000$

$F_B(20\sin(75) + 30\sin(75)) = 7000$

$F_B = \dfrac{7000}{50\sin(75)} = 144.94\ N$

$F_A = F_B\sin(75) - 20 = 120\ N$

$F_C = F_B\cos(75) = 37.51\ N$

$F_A = 120\ N$

$F_B = 144.94\ N$

$F_C = 37.51\ N$