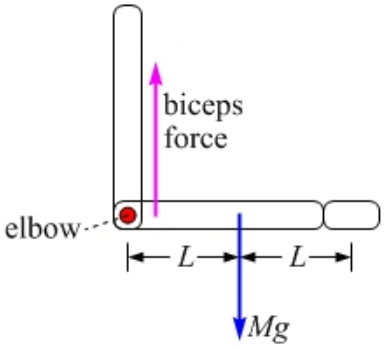
PROBLEM 1 – 20 points

It is often useful to treat the lower arm as a uniform rod of length 2*L* that can rotate about the elbow. The figure shows a simple model of an arm, with the upper arm vertical and the lower arm horizontal.



[10 points] (a) When you are not holding anything in your hand, and your arm is at rest in the position shown, three forces act on your lower arm: the force of gravity (*Mg*), the force exerted by the biceps, and the force exerted at the elbow joint by the humerus (the bone in the upper arm).

(i) Compare the force of gravity with the biceps force. Which has the larger magnitude?

[ ] the force of gravity [ ] the force from the biceps [ ] neither, they're equal

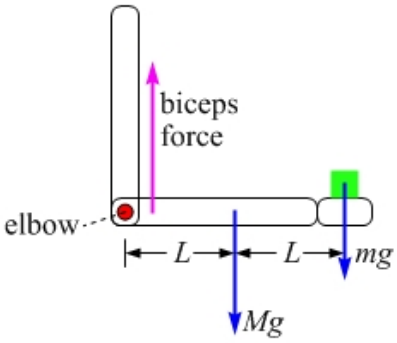
Briefly justify your answer:

(ii) Compare the force from the biceps with the force from the humerus. Which has the larger magnitude?

[ ] the force from the biceps [ ] the force from the humerus [ ] neither, they're equal

Briefly justify your answer:

[5 points] (b) If you place an object in your hand (at a distance 2*L* from the elbow joint), and your arm remains in the position shown, the force from the biceps increases. Assuming the biceps is attached to the arm at a distance of $d = L/5$ from the elbow joint, by how much does the force from the biceps increase if the object has a weight of $mg = 20.0$ N? Your answer should have units of newtons.



[5 points] (c) When the 20.0 N object is placed in your hand, what is the change in the force applied by the humerus at the elbow joint? State both the magnitude (in newtons) and the direction of the change, if there is a change.

PROBLEM 2 – 15 points

Two identical grinding wheels of mass *m* and radius *r* are initially spinning about their centers. Wheel A has an initial angular speed of ω_i, while wheel B has an initial angular speed of $2\omega_i$. Both wheels are being used to sharpen tools. As shown in the figure, for both wheels the tool is being pressed against the wheel with a force *F* directed toward the center of the wheel, and the coefficient of kinetic friction between the wheel and the tool is μ_K. You are holding the tool firmly so that it does not move tangentially to the wheel.

[3 points] (a) If it takes wheel A a time *T* to come to a stop, how long does it take for wheel B to come to a stop?

[3 points] (b) Find an expression for *T* in terms of the variables specified above.

[3 points] (c) If wheel A rotates through an angle θ before coming to rest, through what angle does wheel B rotate before coming to rest?

[3 points] (d) Find an expression for θ in terms of the variables specified above.

[3 points] (e) If you doubled the value of μ_K, how would that affect the time required to stop wheel A?