Lab 6 Biceps Muscle Model

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Theory

- According to the Laws of Statics, all the forces acting on the forearm must satisfy

$$B = (H + \frac{W}{2})\frac{R}{(r\cos\alpha)}, \tag{1}$$

$$A = (\frac{R}{r} - 1)H + (\frac{R}{2r} - 1)W, \tag{2}$$

  where B is the force from the biceps muscle, A is the humerus force from the upper arm, W is the weight of forearm, H is the weight of hand, R is the moment arm of H, and r is the moment arm of B.

Experimental Process

Procedure

Skip step (1)-(4) in the procedure.

(5) Measure the distance between the elbow hole and each of the five biceps attachment holes (r_1, r_2, ... r_5), as well as the distance between the elbow hole and the mass hanger hole at the "hand" end of the forearm bar, R. Record these values:

r_1	r_2	r_3	r_4	r_5	R

(6) Measure the mass of the forearm bar M_{fore} without the upper-arm attachment piece, and record this value and calculate the force W: $M_{fore} =$ ______________ kg, $W = M_{fore}g =$ ______________ N.

(7) Adjust the knurled rings of the gauge so they read zero with no weight attached. Arrange the apparatus as shown in Figure 1, with the biceps gauge attached to the farthest hole from the elbow, which is approximately <u>12 cm</u> from the hole through which the upper-arm gauge passes. When clamping the forearm gauge, make sure the pointer can move freely through its range and is not obstructed by the clamp jaws. Use the small keeper ring with the thumbscrew on the short right-angle section to retain the biceps gauge in position. Attaching the 50-g mass hanger to the end of the forearm bar, add masses in increments of 100 g up to 550 g, and record the readings of the two gauges below.

Since there may be some friction in the gauge which brings it to rest over a small interval of readings, you need to move the mass hanger up and down near its equilibrium position, and record the maximum and minimum readings at which the pointer sticks. The average of these two values is a good estimate of the "true" force, and a half of their difference is a good estimate of the experimental error. Record the maximum reading, minimum reading, average reading, and a half of the difference in readings ("error") in the chart below.

As you change the masses in the "hand," adjust the position of the upper-arm attachment point at the "elbow" so the bar comes to rest in a horizontal position. You may need to push up forcefully on the bar when using the heavier masses, compressing the upper-arm gauge before tightening the attachment.

	Total mass, m	150 g	250 g	350 g	450 g	550 g
	$H = mg$ (N)					
Biceps gauge:	maximum reading					
	minimum reading					
	average reading, B					
	(difference in readings)/2, ΔB					
Upper-arm gauge:	maximum reading					
	minimum reading					
	average reading, A					
	(difference in readings)/2, ΔA					

If you find that there seems to be an unusual amount of friction in your scale readings, check that the scales are not twisted in their clamps. All persons doing experiments in the real world soon realize that nature can be difficult, and not everything works as it is supposed to or according to the sample instructions. Throughout this lab series, you will often need to use common sense and resort to your own ingenuity to get through the parts that don't seem to work quite right.

(8) With a total mass of 150 g hanging from the end of the forearm bar, take readings with the biceps gauge attached to the various holes, which are approximately 4, 6, 8, and 12 cm from the elbow. (The hole at 3 cm is difficult to use, so you DO NOT need to do it.) Each time you adjust to a new position, make sure the bar is horizontal. For certain biceps attachment positions (e.g., 4 cm from the elbow), you may find it necessary to move the elbow attachment point a considerable distance along the upper-arm guage rod, forcefully compressing the gauge to keep the bar horizontal. For each r, obtain the angle α from $\tan\alpha = x/y$ (you already know the value of x, but it will need to extend the lines of the gauge rods to determine the value of y, see p56). Record your results:

distance from elbow, $r = x$	4 cm	6 cm	8 cm	12 cm
y				
$\tan\alpha = x/y$				
$R/(r\cos\alpha)$				
maximum reading				
minimum reading				
average reading, B				
(difference in readings)/2, ΔB				

(9) In Excel, plot a B-versus-H graph using the table in (7). Label the axes with units. Add error bars by double clicking the data points in the graph (see p56) and choosing "Custom" to select the data of error bars. Fit the trend line to verify Eq. (1).Also, make another curve of A-versus-H on the same graph. Add error bars, and fit the trend line to verify Eq. (2).Label the two curves, and title the graph.

(10) Plot a graph of the biceps force B as a function of $R/(r\cos\alpha)$ for the various hole positions r in Excel using the table in (8). Label the axes, add error bars, and fit the trend line to verify Eq. (1).

Question (2 mills)

Skip question 2

1. What is the largest value of the horizontal force, P, that would have arisen in your measurements? Hint: You may need the formula for the horizontal force.